International Journal of Informatics Society

12/12 Vol. 4 No. 3 ISSN 1883-4566

Informatics Society

Aims and Scope

The purpose of this journal is to provide an open forum to publish high quality research papers in the areas of informatics and related fields to promote the exchange of research ideas, experiences and results.

Informatics is the systematic study of Information and the application of research methods to study Information systems and services. It deals primarily with human aspects of information, such as its quality and value as a resource. Informatics also referred to as Information science, studies the structure, algorithms, behavior, and interactions of natural and artificial systems that store, process, access and communicate information. It also develops its own conceptual and theoretical foundations and utilizes foundations developed in other fields. The advent of computers, its ubiquity and ease to use has led to the study of informatics that has computational, cognitive and social aspects, including study of the social impact of information technologies.

The characteristic of informatics' context is amalgamation of technologies. For creating an informatics product, it is necessary to integrate many technologies, such as mathematics, linguistics, engineering and other emerging new fields.

Guest Editor's Message

Tadanori Mizuno
Guest Editor of the Twelfth Issue of International Journal of Informatics Society

We are delighted to have the twelfth and special of the International Journal of Informatics Society (IJIS) published. This issue includes selected papers from the Fifth International Workshop on Informatics (IWIN2011), which was held in Venezia, Italy, Sep 16 - 21, 2011. The workshop was held at Ca' Foscari University. This workshop was the fifth event for the Informatics Society, and was intended to bring together researchers and practitioners to share and exchange their experiences, discuss challenges and present original ideas in all aspects of informatics and computer networks. In the workshop, 27 papers were presented at seven technical sessions. The workshop was complete in success. It highlighted the latest research results in the area of networking, business systems, education systems, design methodology, groupware and social systems.

Each IWIN2011 paper was reviewed in terms of technical content and scientific rigor, novelty, originality and quality of presentation by at least two reviewers. From those reviews, 14 papers are selected for publication candidates of IJIS Journal. This tenth includes four papers of them. The selected papers have been reviewed from their original IWIN papers and accepted as publication of IJIS. The papers were improved based on reviewers' comments.

We hope that the issue would be of interest to many researchers as well as engineers and practitioners in this area.

We publish the journal in print as well as in an electronic form over the Internet. This way, the paper will be available on a global basis.

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Design of An Agent-oriented Middleware for Smart Home

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Abstract - In smart home environment, different kinds of system components including hardware elements, software components, network connections, and sensors are required to cooperate with each other to reduce environmental burden by energy management and to support human's life allow for a comfortable lifestyle. This paper proposes a concept of an agent-oriented middleware for smart home that consists of various home electric appliances and various sensors related to smart grid or micro grid. The agents acquire variety of information, data, etc. from the smart home environment and store/manage them in a methodical manner. Then agents configure and provide the home energy management service, life-support service, multimedia service etc. based on the information and user requests. In this paper, we describe the concept, design and initial implementation based on our agent-oriented middleware. We implemented initial applications related to multimedia and energy management to confirm the effectiveness and feasibility of our middleware to apply for smart home.

Keywords: Multi-agent, Middleware, Smart home, Ubiquitous computing, Life-support system

1 INTRODUCTION

Recently, several challenging works have investigated smart home and service provision on the smart home environment. There are two mainstreams in researches on smart home; one is research on energy management system to reduce environmental burden, and the other is for life-support service construction scheme using various sensor information. In energy management system, researches proposal advanced methods for controlling energy and promoting energy saving to reduce environmental burden [1]–[3]. Additionally, we need to consider the planned blackouts in the area after the Great East Japan Earthquake. On the other hand, in researches on life-support service construction, superior frameworks and schemes

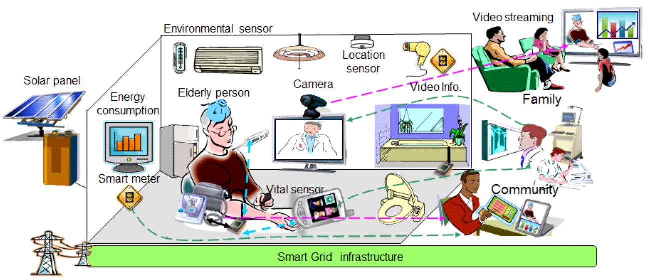

Figure 1: An application of coordination of home electric appliances and various sensors in smart home environment.

are actively challenged for dynamic cooperation among many kinds of system components, i.e., entities in smart home environments and ubiquitous computing environments, to provide user-oriented services [4]–[9].

The discussions on actual applications in smart home have been mainly focused on energy control of home electronics appliances and provision of life-support service, multimedia service, etc. In the future, these services control energy and appliances in user's house, and provide user depending on the situation based on various sensor information and user preference. In other words, we need to utilize various kinds of information to provide life-support service, multimedia service, etc. based on the infrastructure such as Home Energy Management System (HEMS).

We are promoting research and development on fundamental technologies aiming at smart home environment. In smart home environment, the home appliances and various sensors provide in a coordinated manner energy management service, life-support service, and multimedia service. We are targeting at the services such as home care support for elderly people who live alone including watching over, healthcare, safety confirmation, etc. from coordination of home appliances and sensor information as shown in Fig. 1. We are also considering multimedia services such as video streaming or videoconferencing constructed from coordination of computers, home appliances, and smartphone considering Quality of Service (QoS), Quality of Experience (QoE), energy consumption, etc.

As for QoS and QoE, the system needs to satisfy user requirement in smart home environment. To address this, the system has to consider not only selection of the devices (appliances) from user location, but also resource situation of network, software, and hardware including electrical power consumption. This is because resource availability tends to be poor and unstable depending on the device and status of use.

In this research, we are aiming to realize various service construction schemes in smart home in order to provide QoE-aware and energy-aware services against changes of resource status and user's situation. We have proposed an effective handling of multiple contexts including user context and resource contexts [10], [11]. To accomplish the objective, we apply agent-oriented middleware approach.

The overview of this approach is agentification of each entity in overall smart home environment. Basically, agent has context management ability and cooperation ability for conflict resolution on multiple contexts. Agent also has maintenance mechanism for long-term context to accumulate and reuse history and experiences of past cooperation among agents. Agents would make the energy-aware and QoE-aware service provision possible by the individual behavior and the cooperative behavior. As a first step, we described concept of the middleware, and energy-aware and QoE-aware service provision [12]. However we had not confirmed the feasibility and effectiveness in terms of energy-aware.

In this paper, we propose an agent-oriented middleware for smart home environment. Moreover, we describe design of the middleware focusing on the service construction scheme for QoE-aware and energy-aware service provision considering the multiple contexts. We evaluate our proposal from results of simulation experiments. We also introduce the initial implementation of multimedia communication application and home energy management application based on our middleware to confirm the feasibility and effectiveness.

The rest of this paper is organized as follows. In Section 2 we present related work and problem. In Section 3 we describe the motivation and concept of our middleware. The service construction scheme is described in Section 4. The simulation results are presented in Section 5. Moreover some initial applications are illustrated in Section 6. Finally we conclude this paper in Section 7.

2 RELATED WORK AND PROBLEM

2.1 Related work

Many studies have been done on addressing and analyzing the reduction of energy consumption and environmental burden with ICT [13]–[17]. And there are many middleware related to smart home and ubiquitous computing. The existing middlewares, frameworks, and service construction schemes are actively challenged for dynamic cooperation among many kinds of system components. CARMAN [18] considers Mobile News Service (MNS) for mobile users. It provides service based on user mobility, device's performance and user's preference. When the service is provided by a single mobile device, performance of the device is most important for the service. Therefore there are various kinds of works for providing high quality of web service within the limits of device's performance [19], [20]. These works are focusing on provision individual user-centric service using a single mobile device. To provide multimedia service by utilizing the available resources, we found it will be more efficient if multiple devices around the user can be used at the same time, instead of using only a single device.

In other similar works, service is provided by coordination with any devices around user [7], [9]. These frameworks construct the service based on service template which is requested by user. It means they search appropriate function to the requests and cooperation between various devices. Ja-Net [4] also aims to construct emergent service based on user preference.

These works' objective is same as our basic concept in terms of providing the service by coordination with heterogeneous entities. Moreover these works are providing superior mechanism of useful naming system, service description language, service emergence, power management, and sensor system.

We suppose existing service construction schemes are based only on user context and functional components, and they are concentrating on guaranty of coordination and operation or standardization of the specifications. It is important for smart home environment to satisfy a particular requirement and limitation including network resource, computer resource, and energy consumption. In case of rich service provision such as multimedia services in smart home environment, we suppose it is much more important to consider QoE. For instance, there are ever-changing situations like user mobility, device's performance around user, resource condition, and demand response based on energy management system. Therefore, there would be a possibility that devices which are physically very close to the user cannot provide the service due to lack of the resources, even if the devices potentially have good performance. Moreover it's necessary to provide the service in consideration of cooperation problem of unexpected devices, softwares, and network in addition to energy consumption problem.

We concluded that it's required to achieve service construction scheme which considers not only user request but also other situation (context) including user location, environmental information, devices, software, network, and energy consumption in effective and integrated manners.

2.2 Problems

We need to address some technical problems to provide QoE-aware and energy-aware services on smart home environment that consists of computers, audio-visual home electric appliances, and sensors.

Management of resource context

We define "context" as situation of target entity at time t and temporal changes of the situation after/before time t. The situation is represented as internal representation model of the entity. Existing works have been mainly focusing on user context acquisition scheme such as users' locating information. However, in terms of resource of entity, it was treated as only a value of the target resource parameter at time t, not as "context". In smart home environment that consists of many kinds of entities in different level of functionality and performance, it is important to consider resource context efficiently as well for proper QoE control and energy management.

Multiple context coordination

In smart home environment on which heterogeneous entities coexist, QoE and energy consumption should be maintained in the range from entity level to overall system level. Therefore, we have to consider not only functional specification of the entity, but also multiple context coordination including resource context and user context.

Non-deterministic property of service construction

There are mutual dependencies and interoperability among entities that are not resolved deterministically from analysis of static specifications. Each entity is basically designed to work by itself, not designed to work with unknown entities cooperatively. Thus, services constructed from the entities would not work whether entities consistent with applicable specifications.

Effective acquisition of various and amount of information related to smart home

Many wired/wireless sensor devices detect environmental data and vital data in the smart home. For example, there are electrical power consumption, location, vital sign, and brightness in real time. As for home care support service, the information has limitations for obtaining an accurate estimation because the information is obtained by the vital sign limited piece of information on certain individuals. It would be possible to perceive the health condition of elderly person with greater accuracy using physical location of the person, environmental information such as ambient temperature, room brightness, energy consumption, and video information, as well as the vital sign. However, it is difficult to acquire all the information because of the limitation of computational resources and network resources include wireless sensor's battery. Consequently, we need to consider the effective way of information acquisition.

Service provision based on various kinds of information

After acquisition of various kinds of information, effective information and service provision using the information would be a challenge. The data and information including energy consumption, vital sign, location information, environmental information, multimedia data, etc. contain significant diverse aspects in both quantitative and qualitative. Therefore, we need to construct the service provision mechanism include provision of required data and information, and control devices based on data and information.

3 OVERVIEW OF AN AGENT-ORIENTED MIDDLEWARE

3.1 An agent-oriented middleware

In this section, we describe the following three approaches to solve technical problems.

Agentification of each entity

We define "Agentification" as a process making a target entity workable as an agent by adding knowledge processing mechanism. We also add context management ability, cooperation ability to resolve context conflict to the agents, and adaptive communication ability [21]. Moreover, we embed long-term-context maintenance ability to the agents to accumulate cooperation history and experiences.

Multi-context-based Service Construction scheme

To realize QoE-aware and energy-aware service construction considering multiple context, we propose contract-based service construction scheme of agents. Agents make organization based on Contract Net Protocol (CNP) [22]. Moreover, we model heuristics and dependency information on cooperation history in past among agents as long-term context among agents. This kind of context is also managed by the agent. By using this context, agents organize the entities to construct more advanced services employing lessons learned.

Control scheme of demand response based on user policy

To control energy consumption in smart home, we propose the control scheme of home appliances based on user policy and user's situation considering QoE, QoS, energy consumption, and CO_2 reduction.

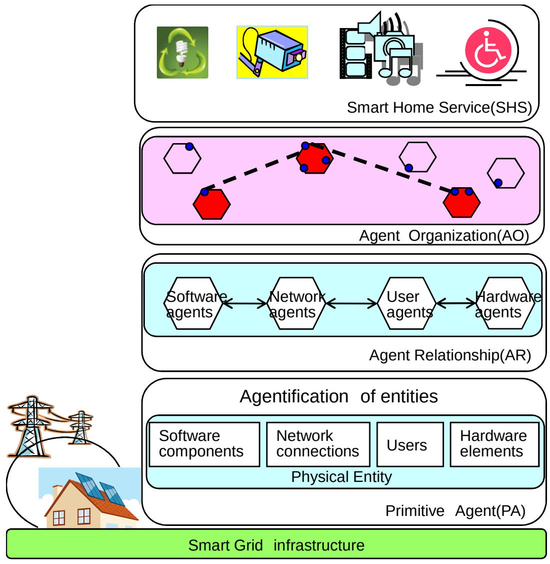

Figure 2: Agent-oriented middleware

The fundamental framework of our middleware is shown in Fig. 2. Our middleware consists of four layers, i.e., Primitive Agent layer (PA), Agent Relationship layer (AR), Agent Organization layer (AO), and Smart Home Service layer (SHS). PA makes physical entities to agents. For instance, the agents have ability to manage context, control sink node of sensor network, selection of communication protocol based on kinds of data and resource situation, etc. in this layer. In AR, inter-agent relationship based on long-term context among agents is created and maintained. In AO, agent's organization is constructed based on the context in PA and AR when user requirement or situation to specific service is issued. On the top layer SHS, actual service is provided to users.

3.2 Process of service provision

Fundamental process to provide service consists of the following steps.

(1) Agentification

Agent's designer adds each entity to domain oriented knowledge representation model that is suitable for classification of the entity.

(2) Updating of IAR

We define long-term context among agents as Inter-Agent Relationship (IAR). Each agent has different IARs to all other agents with which it has cooperated in past time. Each agent updates their IAR after its service provision by itself or by cooperation with other agents.

(3) Self-directive user requirement acquisition

Agent considers and acquires user requirement autonomously. Agent analyzes the requirement from user's profile, location information, behavior, and sensing data in the smart home environment. Agent has to choose in the most suitable manner to get the requirement because useful input devices may not be available in everywhere.

(4) Service construction and service provision

To provide service, agents construct its organization based on CNP. We apply hierarchical CNP, i.e., task announcement is propagated in order of hardware agents, software agents, and network agents. The agent organization is created based on context managed by each agent including sensor devices. The actual service is constructed and provided with combination of entities controlled by agents.

(5) User evaluation

The agent organization receives user's feedback concerning the quality of provided service when the service provision is finished. We introduce us-effectivity (E) based on [4]. In our middleware, when E value changes, each agent informs the update to all other agents that have relationship to it. Therefore, the result of evaluation is propagated to all related agents. It effects to reconstruction of various service and behavior of agent.

4 SERVICE CONSTRUCTION SCHEME

4.1 Basic Inter-Agent Relationship

Basic IAR consists of Tight Relationship, Group Relationship, Competing Relationship, and Positional Relationship like shown in Fig. 3.

(1) Tight-Relationship

Agents create Tight-Relationship (TR) when agents provide some services by constructing organization. It is possible for the agent to have past cases of successes and failures in cooperation by using TR.

(2) Group-Relationship

Group-Relationship (GR) is given to group of agents that have some potential dependencies. For example, there is GR among hardware entities such as sink node and source node of wireless sensor network, smart meter and appliance, desktop PC, speakers, and PC displays, etc. Agent can inform changes in their states frequently to the agents within the group by using GR.

(3) Competing-Relationship

Competing-Relationship (CR) is formed among agents that have same function. The reason we add this relationship is that there are agent's function in direct competition with agent which has same function when task announcement of the function is issued. The competing agents routinely inform their status to each other, and they can make good organization effectively when CNP-based negotiation runs by using CR. Moreover CR has the effect of reduction of messages because agents which have CR send message considering other agents situation.

(4) Positional-Relationship

Positional-Relationship (PR) is formed among agents that have same positional information. For example, there is PR among hardware entities such as smartphone and TV, and network entities such as network location including wireless network, Bluetooth. It is possible for the agents to select the device to provide the service around user.

4.2 CNP-based service construction with IAR

Our scheme which is based on CNP builds agent organization using IAR. CNP is a mechanism to make contract relationship among agents by exchanging messages such as task

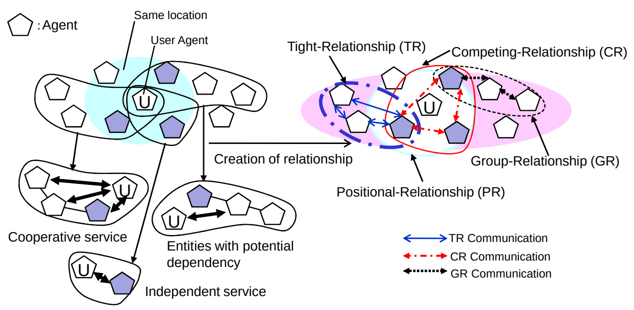

Figure 3: Class of Inter-Agent Relationship

announcement, bid, and award, shown in Fig. 4. In this subsection, we briefly explain features of service construction scheme based on TR, GR, and CR.

(1) Case of TR

In Fig. 4(1), we assume that agent A has a `TR` with both agent B and agent C whereas no IAR exists between B and C. `TR` between A and B indicates that trouble was occurred when they had cooperation in the past, and `TR` between A and C indicates no trouble in the past. They refer to each IAR when B and C receive the task announcement from A. B does not send bid because `TR` against A is bad. That means the trouble in cooperation would occur this time too. On the other hand, C sends bid because C judges from `TR` that it would contribute to the task announced. It is possible to reduce trouble in cooperation by agent considering coordinated relationship in the past.

(2) Case of GR

We assume that agent A has no IAR with both agent B and agent C whereas relationship of type GR exists between B and C as shown in Fig. 4(2). C recognizes that `GR` against B exists when C judges the task announcement from A. Then C sends bid if C judges that B can provide service by referring to `state` in IAR. On the other hand, C ignores the task announcement if B cannot provide service. It is possible to reduce the trouble in cooperation by agent considering dependency of the agents.

(3) Case of CR

In Fig. 4(3), we assume that IAR of type CR exists between agent B and agent C whereas agent A has no IAR with both B and C. B and C receive the task announcement. Each agent checks IAR of type CR if it can process the task. When agent has `CR`, it refers to state of the `CR`. For example, B sends bid in case that B judged the value of `us-effectivity` on this task is higher than that of C. By contrast C ignores the task announcement in case that it judged `us-effectivity` of B is higher than C. In fact, it is possible to efficient construction of service by consideration of state of same function agent.

4.3 Concept of policy-based home energy management

In general, demand response is a control scheme of power consumption of consumers on the electric power provider side. The scheme controls operational status of home electric appliances. We propose a policy-based home energy manage-

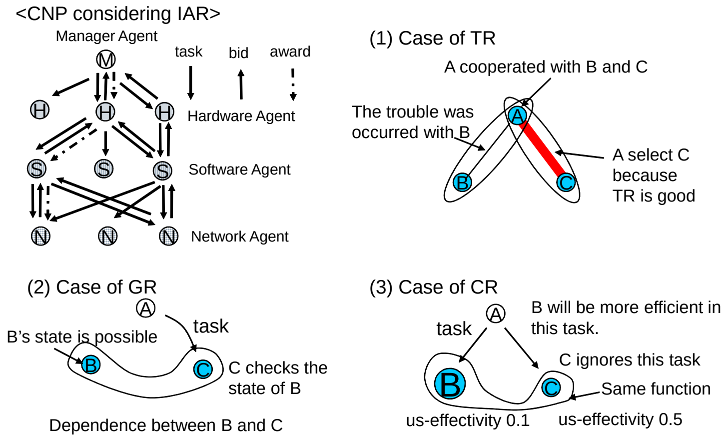

Figure 4: Service Construction based on CNP considering IAR

ment depending on demand response as shown in Fig. 5. The policy of this scheme means user's preference and priorities depending on situation of blackout or load sharing related to demand response. For example, our proposal method controls the air conditioner about the preset temperatures during periods of peak demand for electricity, or turns off air conditioners instead of switching on a fan cut electric power consumption by agents. Additionally our method controls electric pot, microwave, illumination etc. to reduce wasted electricity depending on user's preference and situation.

On the other hand, when the power goes down due to a disaster such as earthquakes, our method controls the illumination, radio, television etc. at a minimum power consumption considering the context such as time, room brightness and the rechargeable batteries. Additionally, when there is no possibility of demand response, our method provides multimedia service using a wide-screen TV and audio equipment based on user's preferences. In fact, each agent calculates the power consumption and CO_2, and agents control appliances based on IAR and user's policy.

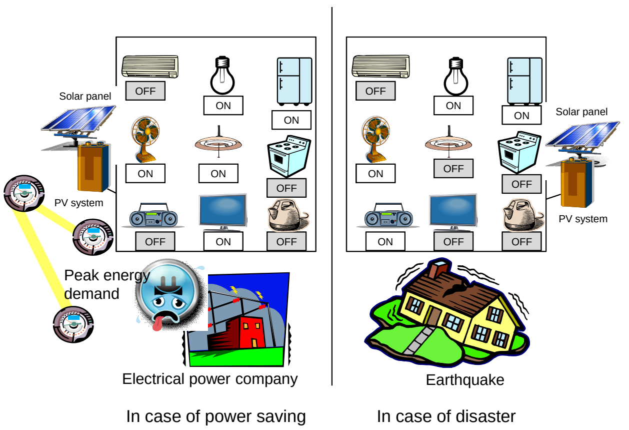

Figure 5: Overview of policy-based home energy management

5 SIMULATIONS

5.1 Implementation

To perform simulation, we implemented agents based on our middleware. We employed agent-based programming environment DASH [23]. We also performed simulation by IDEA [24]. IDEA is interactive design environment for Agent system. We used DASH because agent which is developed for simulation can easily be reused when we build application systems.

5.2 Evaluation method

In this simulation, QoE awareness of the system is measured and we investigate how much the QoE awareness is improved by introducing our middleware. To measure the QoE awareness, we apply User Request Achievement (URA) level. We can measure how much the user requirement is fulfilled by the system. Details of URA are described later.

Figure 6 shows the behavioral situation representation of the system. Here, three entities including a hardware entity, a software entity, and a network entity are making organization and providing service to a User. The user issues "User Request QoE" and the system provides service with "Provided QoE". Hardware Agent (HA) monitors CPU resource context and Network Agent (NA) monitors bandwidth resource context. On the other hand, Software Agent (SA) has knowledge concerning mapping from resource availability onto actual user level QoE.

The QoE evaluation of service is based on URA. URA is calculated by comparison between User Request QoE (RU) and Provided QoE (SV). In this simulation, we defined the range of URA is from -1 to 1. Here, ru_i is an element of RU and it represents User Request QoE on service element i. Also sv_i is an element of SV and it represents Provided QoE on service element i. The value of ru_i and sv_i is from 1 to 10. Here, URA on service element i, i.e. URA_i is represented as follows:

- $SV = \{sv_1, sv_2, ...\}$

- $RU = \{ru_1, ru_2, ...\}$
- $URA_i = (sv_i - ru_i)/10$

If URA_i is above zero, the user requirement is fulfilled. If it is below zero, the requirement is not satisfied. In this evaluation, the number of service elements is assumed to be two ($i = 1, 2$) and URA indicates the total URA, that is, a mean value of URA_1 and URA_2 for simplification.

We performed simulation for 500 times. The agent constructs CR immediately after simulation beginning. When SA constructs service, it refers to NA's bid and IAR. If SA judges that other agent is suitable, it disregards the task even if the task is acceptable. And if agent receives bid by two or more agents that can fulfill user requirement, agent sends award to agent with the highest value of E of IAR after referring to the value of E. The simulation receives an assumed user evaluation each time of service construction. The user evaluation is reflected to E. User evaluation is assumed good if sv_i is within from 120 % to 100 % when ru_i is regarded as 100 %. In this case value E is set to 1. It is assumed bad in case that sv_i exceeds 120 % or is below 80 %, and the value is set to -1. Otherwise it is regarded as usual, and the value is set to 0.

We compare three patterns of agent behaviors, i.e., our proposal (IAR-based approach), the case considering only user context (User-request approach), and the case considering only the maximum QoE value of agent for QoE without consideration of resource context (Maximum approach). Resources of HA and NA are assigned random values in every service construction. We also give tendencies of user request in four patterns, which is high quality (7∼10), middle quality (4∼7), low quality (1∼4), and random quality (1∼10).

5.3 Simulation results and evaluation

Figure 7 - 10 shows the frequency distribution concerning URA. Figure 7 is a comparison for case that RU is always in high, Fig. 8 is a comparison for case that RU is always in middle, Fig. 9 is a comparison in case that RU is always in low, and Fig. 10 is a comparison in case that RU is always in random numbers.

From analysis of Fig. 7 in case that RU is always in high, our approach could achieve the user requirement with higher frequency than User-request approaches. In case that user requirement is higher than the service environment, it can be understood that the requirement cannot be fulfilled even if

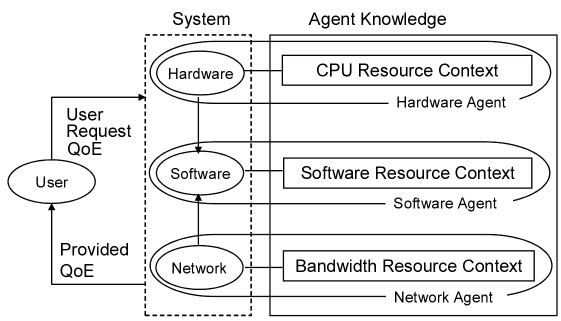

Figure 6: Behavioral situation representation of the system

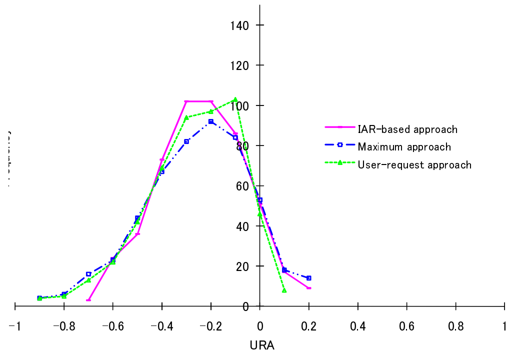

Figure 7: Results of comparison in case that RU is always in high

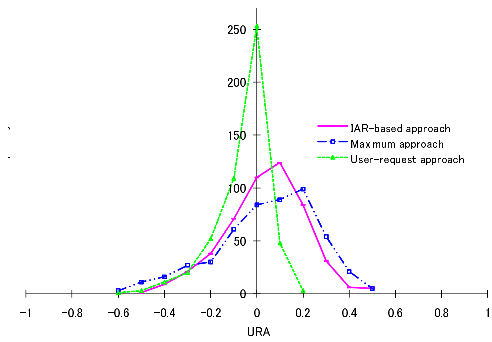

Figure 8: Results of comparison in case that RU is always in middle

only user context is considered. Moreover, in case that agent considers only the user request and the maximum value that can be selected, URA generally is lower than our approach, when user requirement is not fulfilled. It is understood that some conflict on resource context is occurred. Our approach also decreases bad service construction by considering IAR. This is because that IAR decreases the conflict of resource context. From these results our approach is rather effective in this kind of case.

From analysis of Fig. 8 in case that RU is always in middle, URA of User-request approach often closes to zero much more times than other approaches. On the other hand, compare to the User-request approach, IAR-based approach could fulfill the user requirement frequently. Moreover the case that URA of our approach is higher than that of Maximum approach is a little. From this result, if resources are available, our approach can provide a slightly better service than the original user requirement. We can find our approach considerably reduce bad service construction than other approaches such as in Fig. 7.

By analyzing Fig. 9 where RU is always in low, URA of User-request approach often extremely close to zero more frequently than other approaches. In our approach and Maximum approach, the case that URA closes to zero is not frequent. But, our approach closes to zero much more times than Maximum approach. Moreover User-request approach

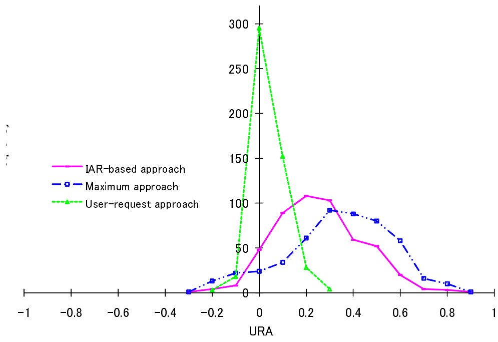

Figure 9: Results of comparison in case that RU is always in low

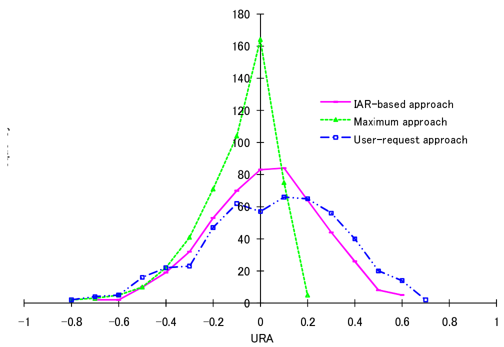

Figure 10: Results of comparison in case that RU is always in random numbers

and our approach reach much closer to zero than Maximum approach. We can find that the agents construct organization considering user requirement and IAR effectively. However, our approach is thought to be meddlesome service for user who does not want excessive quality.

By analyzing Fig. 10 where RU is always in random numbers, URA of User-request approach extremely close to zero more frequently than other approaches. In our approach, URA closes to zero and 0.2. Our approach also closes to zero much more times than Maximum approach. In negative side of URA, User-request approach generally is lower than our approach. Moreover, in Maximum approach, the case that URA closes to zero is not frequent. We can find that our approach that the agents try to construct organization to fulfill user requirement while avoiding low URA possible.

From these simulation results, it is understood that our approach is most effective under unstable environment with high-level user requirement. Additionally, it should be considered whether user requirement or relationship between agents which has the higher priority, when agents construct service. User requirement can be fulfilled by mainly considering IAR rather than user requirement in the environment with high user requirement and unstable resources. However, in the environment with suitable user requirement and stable resource, user requirement should be mainly considered rather than IAR. Therefore, we suppose that it is necessary to consider top priority between user requirement and IAR so that it matches to the situation when service is constructed in smart home environment.

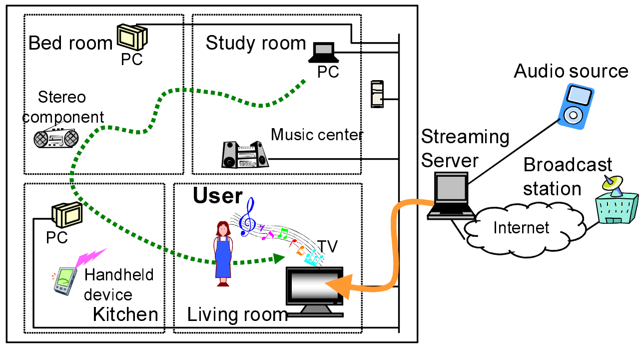

Figure 11: Overview of music distribution service

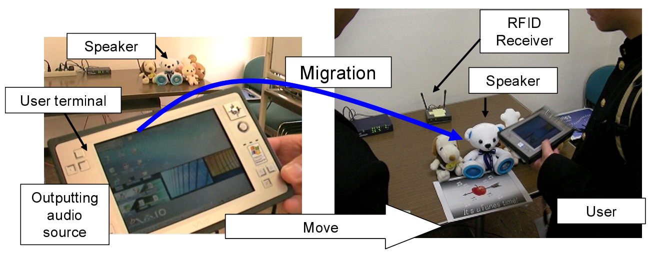

Figure 12: Snapshot of music distribution service

6 APPLICATIONS

6.1 Entertainment Application

We developed four applications based on our middleware to confirm that the middleware can apply to a broad range of smart home services. One is contents services. These applications are in the entertainment application domain. The other is an initial home energy management service.

The first example is a music distribution service as shown in Fig. 11. This service plays music through various speakers, by following the user's movement. As for hardware configurations, we used an active-type RFID system for sensing user's location. We equipped RFID receivers behind each speaker.

In Fig. 12, a user is carrying a user terminal with a tag of RFID. At this time the user is playing music on the user terminal. When the user approaches to the speaker on the table, the music migrates from the user terminal to the nearest speaker. Speaker agents provided the service considering CR of IAR and user location.

The second example is a jam session service as shown in Fig. 13. It is an entertaining and tangible application that can be enjoyable for the people in the range from the children to the elderly. A user selects some paper cups on which RFID tag attaches. On the cup, a picture that represents an instrument is shown. When the user closes the cups to the speakers, the speaker plays instrumental audio sources corresponding to the paper cup's instrument picture, such as dram, piano,

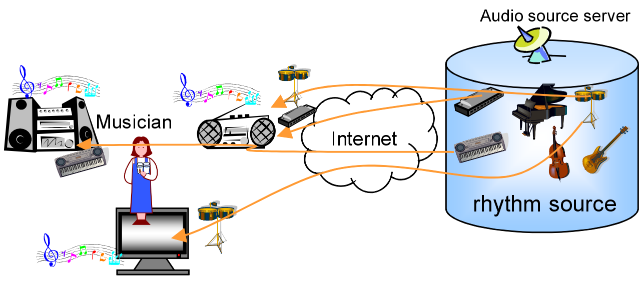

Figure 13: Overview of jam session service

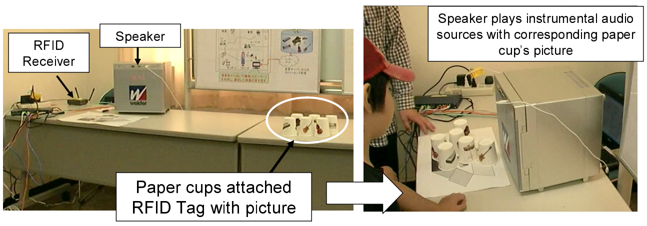

Figure 14: Snapshot of Jam session service

guitar, harmonica, and synthesizer, via the Internet as shown in Fig. 14. If the user moves the paper cups away from the speaker, the speaker stops playing instrumental audio sources corresponding to the paper cup's instrumental picture. Therefore, the user can play instruments by combining some paper cups. The agent's organization of this system was constructed by RFID agents, Comp. agents, AudioPlayer agents, Speaker agents, etc. In fact, we used two speakers, two RFID readers, and six RFID tags. This service was tried by more than 90 visitors at our laboratory's open house. This system could continue to provide service without experiencing any problems.

The third example is a multi-contents service as shown in Fig. 15. This application plays multi-contents by combing various contents from each server. Basically, we reused agents and function of music distribution service and jam session service to this system. And we added video streaming function. For example, when agent plays a slide show content on the display, the display agent call a music player agent. Then a music player agent plays a music content. We feel a single application running. In fact, agents combine a single content with another single content at the same time.

Figure 16 shows a snap shot of multi-contents service. When a child put a paper cup on the display stand, the system plays a music content and a slide show content on the display in Fig. 16 (Case 1). If the child moves the paper cup away from the display, the system stops to play the slide show contents and the music contents.

In Fig. 16 (Case 2), the users put three paper cups. The system plays two slide show contents, live video streaming and two music contents. When the users move three paper cups away from display, the system stops to play all contents. Additionally, this service was tried by more than 110 visitors at our laboratory's open house. This service could continue to work without experiencing any problems.

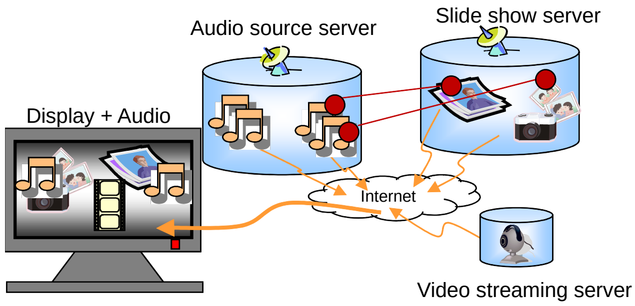

Figure 15: Overview of multi-contents service

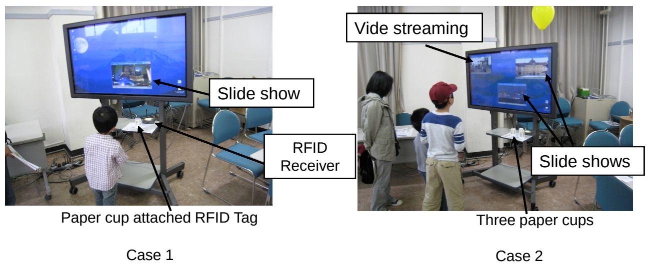

Figure 16: Snapshot of multi-contents service

From this multi-contents service, we confirmed that our middleware can treat various contents in parallel using smart home devices. We confirmed feasibility and effectiveness of our middleware based on IAR through three applications.

6.2 Home Energy Management Application

For initial experimental analysis and performance evaluation of energy management, we developed an energy management application using humidifier and environmental sensors. This energy management application controls electric power of the humidifier depending on degree of humidity and illuminance level. Figure 17 shows the experimental environment.

This application consists of humidifier, humidity sensor, light sensor, smart tap, solid state relay (SSR), and PCs. This humidifier is simple-function device. Therefore the humidifier does not have automatic adjusting function depending on the degree of humidity. We used e!NODE [25] developed in Mineno laboratory, Shizuoka University, Japan as the smart tap and SSR module. We also employed Phidgets sensor Kit [26] as the light sensor.

We performed this experiment in our laboratory. We used illuminance level of the light sensor to judge whether someone is in this room. When someone is in this room, we set the humidity operates. This will help to reduce waste of power consumption. In this experimental scenario, the application will start only if the value of degree of humidity is below 50% and the illuminance level of the light sensor exceeds 550. On the other hand, the application will stop if the value of degree of humidity is exceeds 50 % or the illuminance level of light sensor is below 200.

Figure 18 shows the experimental result. The horizontal axis is measured time, and the vertical axis shows electric

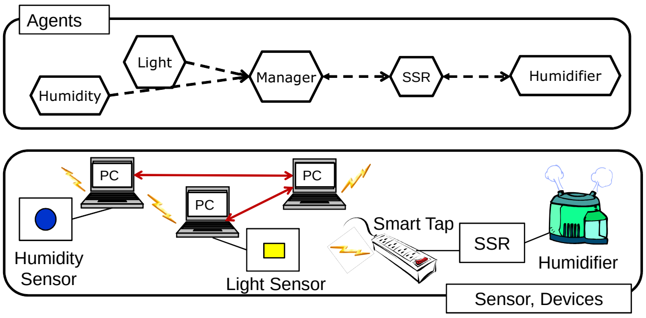

Figure 17: Experimental environment of energy management

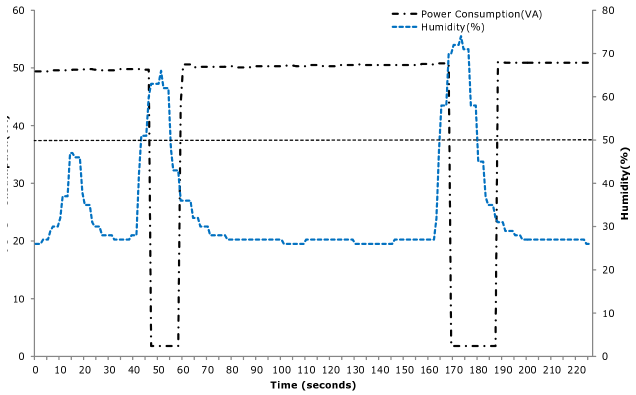

Figure 18: Power consumption and degree of humidity

power consumption and humidity. Electric power consumption decreased to around 0 VA when humidity increased after around 45 seconds and 170 seconds. It seems that this is caused by the reason that manager agent recognized humidity exceeded 50 % and turned off the SSR module to stop the humidifier. On the other hand, Electric power consumption increased to around 50 VA when humidity decreased after around 60 seconds and 190 seconds. Because the manager agent recognized humidity was below 50 % and turned on the SSR to start the humidifier.

It seems that this was caused by the reason that manager agent recognized humidity fell below 50 % and turned on the SSR module to start the humidifier. The execution time for the electric power control was about 3 seconds, thus it was proved that the response time was in acceptable range for practical use.

From this initial experimental analysis and performance evaluation of energy management, we confirmed that our middleware can apply home energy management service using home electric appliance and various sensors.

7 CONCLUSION

In this paper, we described the concept of an agent-oriented middleware for smart home environment. We designed our middleware focusing on the service construction scheme for QoE-aware and energy-aware service provision considering the multiple contexts. We also evaluated our scheme with some simulation experiments and confirmed its usefulness in smart home environment, particularly for multimedia services. Moreover we implemented entertainment application and home energy management application as a first step towards practical use of our middleware. And we performed some empirical studies with prototype system concentrating on evaluation of the effectiveness and performance evaluation of energy management.

In future, we would like to design detail method and algorithm of policy-based energy management according to various situation. We are also planning to consider data fusion mechanism and evaluate prototype system using a number of smart taps and environmental sensors.

ACKNOWLEDGEMENT

This work was partially supported by Grants-in-Aid for Young Scientists (B), 23700069. Home energy management application used autonomous distributed cooperative ubiquitous sensor network developed in Mineno laboratory, Shizuoka University, Japan. Special thanks to associate professor Mineno who contributed and implemented the prototype.

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(Received February 29, 2012)
(Revised March 3, 2013)

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A Cloud Type High-Definition Television Conference Service for Heterogeneous Clients with Various Signaling Control Protocols

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Abstract - In order to reduce CO_2 emissions, Technologies of "Green by ICT" are now attracting attention from various fields. HDTV conference system is one of the approaches, because movements of automobiles are inhibited by the use of HDTV conference systems. However, the existing HDTV conference clients cannot be connected with each other, if each client is produced by different vendor, due to the issues related to communication protocols.

To solve these issues, this paper proposes a cloud-type interconnection service for heterogeneous HDTV conference clients, named *CISHDTV*, and evaluates the service. The proposal is one of the results of "Kurihara Green Project", which is a subsidized project by the Ministry of Internal Affairs and Communications Japan in 2010. CISHDTV is realized with Multi point Control Unit (MCU) and SIP conversion Gateway, and is provided to HDTV conference users beyond a public IP network.

Our demonstration experiments show a feasibility of the CISHDTV, and achieve a reduction of more than 80% CO_2 emissions in the case of a staff-training in Kurihara-City in Japan, where several branch offices are dispersed widely. We are now discussing the CISHDTV in the multimedia sub working group of TTC in detail, towards an international standardization.

Keywords: HDTV Conference system, SIP, H.323, MCU, Reduction of CO_2 emissions.

1 Introduction

"Green by ICT" is now attracting attention from various fields [1]. "Green by ICT" is an approach to inhibiting movements of automobiles/people, thus it is expected to reduce negative effect on the environment. "*Kurihara Green Project*" [3]–[8] in Japan is one of the projects promoted with "Green by ICT". The project especially forces on reducing CO_2 emissions in rural area instead of metropolitan area [9]. Rural cities such as Kurihara often have a distinctive structure, called "*Cluster-Type*" [10], in where several down towns are located separately. Hence, the people living in such a rural area have to depend on automobiles in their daily life. Therefore, it is important to limit the use of automobiles to reduce CO_2 emissions.

Television conference system is one of the approaches to reduce CO_2 emissions distinctly. Nowadays, several companies and/or communities have been introduced TV conference systems for the purpose of reducing the costs about business trip. However, existing TV conference systems produced by different vendors may not be interconnected with each other. In an interconnection of existing TV conference systems, there are several issues caused by a different implementation of communication protocols [2]. One is the issue caused by that the existing HDTV conference systems support multiple signaling protocols, such as H.323, SIP and SIP extensions. Another is caused by that the implementation of HDTV conference systems are different form one another, even though the systems are implemented based on same standardized protocol. And the other is caused by that each HDTV conference system supports different video codecs respectively. Because of these issues, a group which uses a HDTV conference system has to continue to use the same products.

To solve these issues, this paper proposes "Cloud-type Interconnection Service for heterogeneous HDTV conference clients (*CISHDTV*)". The CISHDTV utilizes "Multipoint Control Unit (*MCU*)" and "Protocol Convergence GateWay (*PCG-W*)". The service is offered for users beyond a public network on their demands. The service makes HDTV conference systems more convenient, and reduces CO_2 emissions significantly.

The rest of the paper is organized as follows. Section 2 explains the overview of the HDTV conference systems, and points out their interconnection problems. Section 3 proposes an interconnection service of heterogeneous HDTV conference clients beyond a public IP network. Section 4 evaluates the proposed service in terms of its feasibility and reduction of CO_2 emissions. Finally, Section 5 concludes the paper.

2 Interconnection Issues in HDTV Conference System

This section describes about the technologies related to HDTV conference systems at first, and then points out the issues of their interconnections.

2.1 Technologies related to HDTV Conference Systems

Screen resolution of High-Vision (HDTV) is 1,920 x 1,080 pixels, thus it requires 786Mbps information transmission rate [13] to transmit images over networks. Therefore, HDTV conference system requires high video compression technique, because current internet access speed by optical fiber (FTTH) is 100Mbps or less. When a HDTV conference is held with more than three sites, MCU is required as a central apparatus for images and sounds.

HTDTV conference system is usually utilized on IP networks such as the Internet. Especially in a business use case, the system is utilized on a Virtual Private Network (*VPN*) to keep the communication's security. Besides the above, the system also can be utilized on Next Generation Network (*NGN*) [11] or *HIKARI Denwa* [12]. NGN is a next generation communication infrastructure, which keeps the reliability and the stability that the traditional public telephone network provides. NGN also keeps the flexibility and the economic efficiency that IP networks provide. HIKARI Denwa is an IP based public telephone service. HDTV conference clients can connect with each other over HIKARI Denwa with the 0AB ～J telephone number.

HDTV conference system generally employs either Session Initiation Protocol (*SIP*) or *H.323* as a signaling control protocol. The SIP can be used for creating, modifying and terminating two-party (unicast) or multiparty (multicast) sessions consisting of several media streams [14], [15]. The existing SIP clients are generally implemented based on RFC3261 or RFC2543. In SIP, since only session control methods are defined, protocols such as the Real-time Transport Protocol (*RTP*)[16] and Session Description Protocol (*SDP*)[17] are utilized to transmit not only video/voice packets but also information of media-ability. The HIKARI Denwa also uses the extended SIP, named *NGN-SIP*, which is enhanced from a viewpoint of securities. However, to prevent security incidents, NGN-SIP does not allow some SIP methods which are generally used between HDTV clients and MCU.

H.323 is a recommendation from the ITU Telecommunication Standardization Sector (*ITU-T*), and defines the protocol sets to provide audio-visual communication sessions on IP networks[18]. Since the recommendation of H.323 was firstly approved in 1996, a lot of H.323 clients have been appeared on the market one after another. H.323 has high affinity with the traditional public switched telephone network. However, because the protocol structure of H.323 is quite complicated, H.323 isn't suitable for internet technologies, and it cannot scale. Therefore, today, the SIP is the major signaling control protocol, instead of H.323.

2.2 Interconnection Issues of HDTV Conference Clients

2.2.1 The Connectivity between Different Signaling Control Protocols

An interworking technology between H.323 clients and SIP clients have been studied since the SIP had attracted the attention. For example, an equipment which helps interworking of the clients, such as "Session Border Controller(*SBC*)" had been produced. As regards the requirements for the interworking technology, RFC4123 was defined as SIP-H.323 Interworking Requirements. However, in the interworking with the SBC, media capability exchange-timing causes a serious issue in an interworking of two clients. Each signaling control protocol defines original session initiation procedure, respectively. As shown in Table 1 and 2, H.323 and SIP have two session initiation procedures with different exchange-timings of media capability.

Table 1: The capability exchange-timings in H.323.

	Capability Exchange-Timings
Fast Start	Client offers its media capability in H.225 / SetUp
Slow Start	Client exchanges its media capability with H.245 / Terminal Capability Set messages. Most H.323 HDTV clients support this method. (General initiation procedure of H.323.)

Table 2: The capability exchange-timings in SIP.

	Capability Exchange-Timings
Early Offer	Client transmits available codecs and bandwidth which is described in SDP of INVITE. Most of SIP HDTV clients support this method. (General initiation procedure of SIP.)
Delayed Offer	Client offers its media capability with 200OK, as a response of the Initial INVITE without SDP (no offer of capability).

As shown in these tables, because H.323 clients and SIP clients support different exchange-timings of media capability, these clients cannot connect each other in many cases. It needs a combination of "Fast Start" and "Early Offer" or a combination of "Slow Start" and "Delayed Offer" to connect H.323 and SIP clients.

2.2.2 Difference between Implementations and Standardizations in the same Protocol

As described in Section 2.1, SIP and its extensions are defined in various RFCs. In addition, SIP relevant protocols, such as RTP and SDP, has been continually revised. These continually-updating standards make it more difficult to interconnect SIP clients, because fundamental standard of SIP client differs according to the time of their development, even if they are developed by the same manufacturer.

Moreover, various implementations of many manufacturers prevent interconnection of clients. The SIP is a text based protocol, thus it can be implemented easily to conference systems. On the other hand, the text based protocol brings about ambiguities of SIP definition. For example, there is no restriction of characters in the SIP description. And the number of strings is not defined clearly. Due to these ambiguities, each manufacturer uniquely implements with their own interpretations. Therefore, the interconnection of SIP clients becomes more and more difficult. Similarly, an interconnection issue is also caused by the original SIP implementations in a communication network infrastructure. For example, several SIP clients are available with HIKARI Denwa. However, these clients cannot be connected with each other, if the vendor

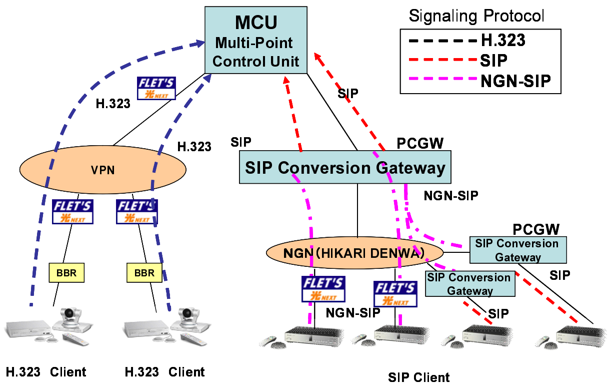

Figure 1: Overview of CISHDTV.

which provides the client differ from each other.

2.2.3 Difference of Implemented Video Codecs

An inconsistency in video codecs or communication rate often causes an interconnection issue of HDTV conference clients. The number of audio codec types is limited. Meanwhile, there are a lot of video codec types such as H.261, H.263, H.263+, H.264 and so on. Therefore, most of HDTV conference clients support a part of these video codecs based on their vendor's policy. As a result, HDTV conference clients cannot be connected with each other, because the clients cannot negotiate video codecs each other.

Similarly, a difference in communication rates supported by clients causes another issue of their interconnection, because each client specifies audio/video communication rate at its negotiation phase.

3 A Cloud-type Interconnection Service for Heterogeneous HDTV Conference Clients

To solve the issues as mentioned in Section 2, we propose a cloud-type interconnection service for heterogeneous HDTV conference clients, named *CISHDTV*, in which heterogeneous clients can be interconnected over public IP networks. Figure 1 shows an overview of CISHDTV. The CISHDTV can improve the users' convenience, in which the users can call a destination client on their demands with the 0AB～J telephone number, and the cost is charged at a metered rate. The realization of temporal HDTV conference with any destination is greatly expected to stimulate a latent demand of users. As a result, HDTV conference will gradually substitute for traditional face to face meeting, and it greatly contributes to reduce CO_2 emissions.

3.1 Interconnection between Different Signaling Control Protocols

We propose a MCU rental service beyond IP networks for the general public users on their demand. In the service, SIP and H.323 clients interconnect each other through the MCU. MCU generally adjusts to various signaling control protocols, video codecs, transmission speeds, resolutions of picture, and so on. MCU can close not only the gap between SIP and H.323 but also the gap between the different abilities of various clients. Through an intervention of MCU, the issue of the timing of capability-exchange between SIP and H.323 as mentioned in Section 2.2.1 can be solved. In CISHDTV, the usage fee is charged based on the total length of time that the MCU service is used.

H.323 clients generally locate on a closed VPN to keep their conference session secret, because NGN and Hikari Denwa do not provide a conference service for H.323 clients. NGN-SIP clients are directly connected to HIKARI Denwa network with its User-Network Interface (*UNI*), and call a destination client with the 0AB-J telephone number. SIP clients are connected to HIKARI Denwa through a Protocol Convergence GateWay (PCGW) which exchange NGN-SIP to SIP. CISDHTV service provider provides a socket connection interfaces to MCU with PCGW for SIP client users.

3.2 Translations for the Differences of SIP Implementation

We propose the method that PCGW bridges the difference of SIP implementation, to solve the issues as mentioned in Section 2.2.2. The PCGW can translate the SIP based on RFC3261 into the NGN-SIP and vice versa. The PCGW can also bridge the differences of SIP implementation of clients. The PCGW supports both extension call and outside call. The existing SIP HDTV clients can connect to MCU over HIKARI Denwa with the PCGW. In CISHDTV, MCU is connected to HIKARI Denwa through the PCGW with 0AB-J telephone numbers. If a client calls to provider's PCGW with a phone number, the PCGW forwards the call to the suitable MCU, according to the configuration of call forwarding.

The existing HDTV conference clients generally use the SIP INFO Method [21] to transmit various information and control commands. However, the SIP INFO Method is not allowed to use in NGN/HIKARI Denwa (NGN-SIP) because of some security reasons. The PCGW encourages an interconnection of HDTV conference clients by its protocol translation function from SIP to NGN-SIP and vice versa.

3.3 Interconnection of Different Codecs

We propose a method that the MCU adjusts the difference of video codecs and/or communication rates that each client supports, to solve the connectivity problem as mentioned in Section 2.2.3. MCU supports a lot of video codecs and communication rates, so as to connect various clients. Therefore, MCU adjusts a video codec and/or a communication rate to the needs of the opposite client. For example, in the case where the caller A which supports video codec AA calls to callee B which supports BB through the MCU, the MCU negotiates A with AA and B with BB respectively.

4 Experimental Evaluations

In this section, at first we verify the proposed CISHDTV in terms of clients' connectivity through demonstration experiments at Kurihara-city in Miyagi Prefecture ,Japan. Kurihara-city constructs a typical decentralized city, called cluster-typed

Table 3: The list of used equipments

Category	Manufacturer	Equipment	Remarks
SIP client	Panasonic Communications	HD-COM (KX-VC500)	
NGN-SIP client	Panasonic Communications	HD-COM (KX-VC500)	Mode Switching
H.323 client	Sony Business Solution	PCS-XG80	
MCU	Cisco Systems (Tandberg)	Codian4520	20Ports
SIP Conversion GW	NTT Software	Crossway	

configuration. Next, we evaluate it for the reduction of CO_2 emissions based on an environmental assessment method.

4.1 Experimental Environments

Table 3 shows the list of equipment used in this experiments. We adopted a HDTV communication unit "Panasonic KX-VC500"(*HD-COM*) [22] which supports full HD(high definition) quality in a conference. It can select a signaling protocol from either SIP or NGN-SIP mode, by a flip of its switch. We also adopted a HDTV conference system "SONY PCS-XG80"(*XG80*) [23], which supports only H.323. Each client in this experiment is located as shown in Fig. 2. The access line of each location is Flet's Next[24], and it connects the clients to NGN and HIKARI Denwa service. H.323 clients are connected with Flet's VPN Wide, which is a public VPN service. The video codec of HD-COM is the H.264 High profile. Available resolutions of HD-COM are 1,920 x 1,080p, 1,280 x 720p and 704 x 480p. Besides HD-COM supports not only SIP but also NGN-SIP, so it can be used as a HIKARI Denwa client with the 0AB-J telephone number.

We also adopted the *Crossway*[19] as a PCGW. The Crossway is prepared for NGN-UNI (HIKARI Denwa) and NGN-SNI(application Server - Network Interface), thus we can use an existing HDTV conference clients on NGN through the Crossway.

Crossway realizes high connectivity, and it can connect with the policom, the tanbarg, the Sony and the HITACH high-tech clients. These four manufacturers occupy about 94% of share of SIP clients. The Crossway also can connect with the NGN-SIP clients such as the NEC and the Cisco. However the Crossway does not warrant the connectivity with HD-COMs.

4.2 Experimental Results

The evaluation experiments are executed in three steps below.

1) Interconnect test between SIP and NGN-SIP clients

2) Interconnect test between SIP/NGN-SIP client and MCU

3) Interconnect test between SIP/NGN-SIP client and H.323 client through MCU

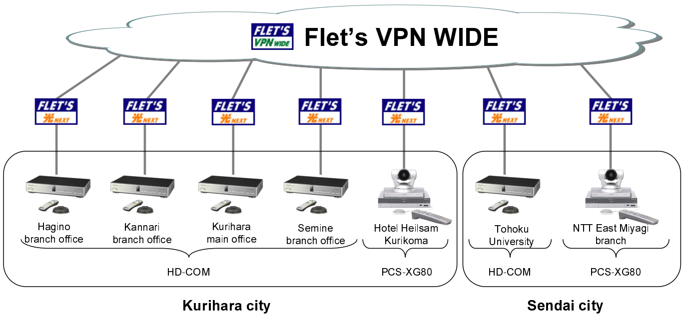

Figure 2: The deployment of HDTV clients.

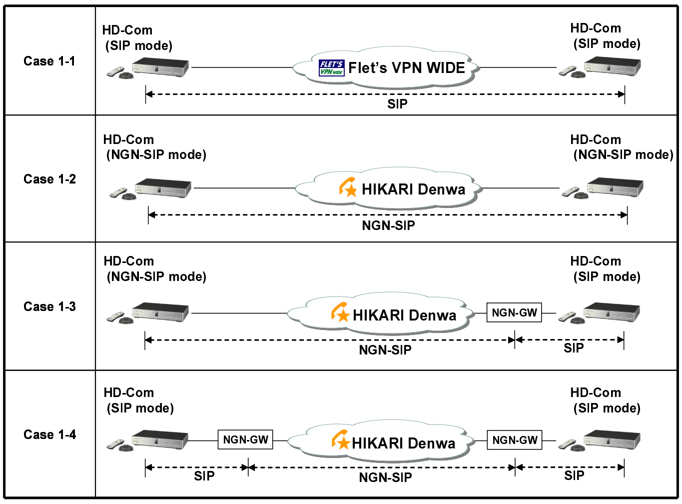

Figure 3: Connectivity tests between SIP and NGN-SIP clients (STEP1).

In the experiments, we confirm the messages of signaling protocols during a conference session. We also measure and analyze the messages related with video and voice during a HDTV conference for over 30 minutes.

4.2.1 Connectivity of SIP Client with NGN-SIP Client (STEP1)

At first, we try to connect HD-COMs to each other with SIP and NGN-SIP mode. Figure 3 shows the test pattern of this connection. When HD-COM runs in SIP-Mode, HD-COM connects to HIKARI-Denwa through Crossway as a NGN-GW(PCGW).

[Case 1-1]

Caller HD-COM(SIP-Mode) calls to callee HD-COM(SIP-Mod) with IP address.

[Case 1-2]

Caller HD-COM(NGN-SIP) calls to callee HD-COM(NGN-SIP) with the 0AB-J telephone number.

[Case 1-3]

Caller HD-COM(NGN-SIP) calls to the opposite Crossway with the 0AB-J telephone number. In this case, the called Crossway with the 0AB-J telephone number calls the destination HD-COM(SIP) with the extended number which is associated with the 0AB-J number in advance.

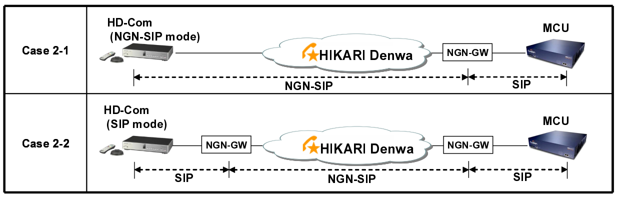

Figure 4: Connectivity test of SIP/NGN-SIP client with MCU (STEP2).

[Case 1-4]
Caller HD-COM(SIP) calls to the opposite Crossway with the 0AB-J telephone number. In this case, the called Crossway with the 0AB-J telephone number calls the destination HD-COM(SIP) with the extended number associated with the 0AB-J number in advance. The caller HD-COM corresponds to an extension client of the Crossway.

The results from those four cases show that the interconnection of HD-COM with SIP/NGN-SIP modes does not cause any problems from the point of signaling control protocol level and picture transfer protocol level. The results also prove that the interconnection between HD-COMs actually is very practical. It is clear that the Crossway can translate SIP of HD-COM into NGN-SIP and vice versa.

4.2.2 Connectivity of SIP/NGN-SIP client with MCU (STEP2)

In the STEP2, HD-COM in SIP/NGN-SIP mode connects to MCU. Figure 4 shows the test pattern of this connection. This experiment confirms that Crossway can translate the vendor original SIP implementations, and also confirms the connectivity of Crossway with various SIP clients in codec level.

[Case 2-1]
Caller HD-COM(NGN-SIP) calls to the MCU. Specifically, HD-COM(NGN-SIP) calls to the opposite Crossway with the 0AB-J telephone number, and the Crossway calls the MCU with the extended telephone number which is associated with the 0AB-J number in advance. In the case 2-1 and 2-2, we confirm the video pictures, which are fed back through the MCU, on the caller HD-COM.

The experimental results show that the interconnection of HD-COM works correctly from the point of Signaling Control Protocol level. However we also confirmed that image noise in Fig. 5 was shown, sometime after a session is established.

[Case 2-2]
Caller HD-COM(SIP) calls to the MCU. Specifically, the Caller HD-COM(SIP) dials a 0AB-J telephone number to connect opposite Crossway, and the called Crossway calls the MCU using the extended telephone number associated with the 0AB-J number in advance.

These results show the interconnection between HD-COM and MCU works correctly from Signaling Control Protocol level, and image noise does not confirmed at all.

Figure 5: Image noise on the caller HD-COM

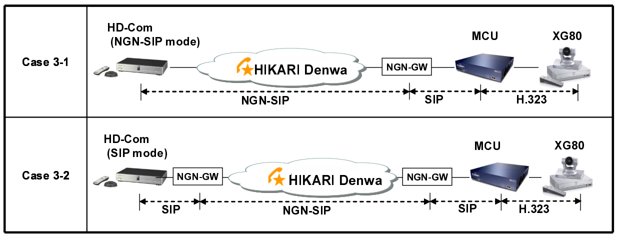

Figure 6: Connectivity tests of SIP/NGN-SIP client with H.323 client through MCU (STEP3)

4.2.3 Connectivity of SIP/NGN-SIP client with H.323 client through MCU (STEP3)

In STEP3, HD-COM connects to H.323 client XG80 through MCU. Figure 6 shows the test pattern of this connection. Here HD-COM and XG80 connect to the MCU respectively, according to appointment information of meeting on the MCU.

[Case 3-1]
The caller HD-COM(NGN-SIP) dials a 0AB-J telephone number to connect to MCU beyond the HIKARI Denwa network. The XG80 dials an extended telephone number to connect to MCU beyond a VPN.

The experimental results show that the message connection between HD-COM and XG80 through MCU works correctly from the point of Signaling Control Protocol level. However we also confirmed image noise such as caused in case 2-1, sometime after a session is established.

[Case 3-2]
The caller HD-COM(SIP) dials a 0AB-J telephone number to connect to MCU beyond the HIKARI Denwa network. The XG80 connects to MCU with the same fashion of case 3-1.

The experimental results show that the message connection between HD-COM and XG80 through MCU works correctly from the point of Signaling Control Protocol level. In addition, image noise such as case 3-1 does not occur at all.

4.2.4 Discussions about the occurrence of image noise

In the test cases 2-1 and 2-2, image noise is appeared sometime after a conference session is established. Hence, we captured the messages transmitted between HD-COM and MCU with wireshark [20], and analyze these. As a result, it is clarified that the transmitted messages which HD-COM requests

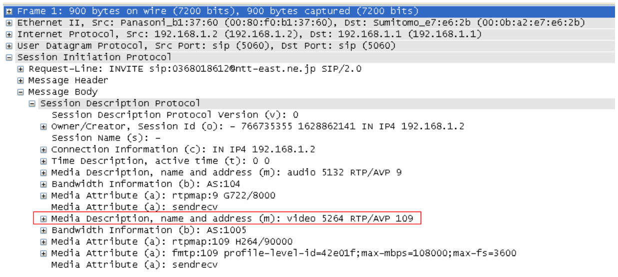

Figure 7: Initial INVITE messages transmitted from caller HD-COM (NGN-SIP mode).

an opposite equipment to redraw its video image, does not arrive at MCU.

HD-COM requests the destination clients to redraw video pictures with RTP/AVP [25]. In fact, HD-COM transmits the RTCP messages to notify the destination clients that a video image has changed significantly. However, even though the Crossway received the messages from HD-COM, the Crossway could not forward the messages to MCU. Figure 7 shows the Initial INVITE message of SIP, which is transmitted from HD-COM. In this figure, Media Description is described as ”video 5264 RTP/AVP 109” in a part of Session Description Protocol(SDP). Although the Crossway supports only RTCP-Based Feedback (RTP/AVPF) [26], it does not support the RTP/AVP.

These results revealed that it is necessary for HD-COM to support RTCP-Based Feedback (RTP/AVPF) or for the Crossway to support RTP/AVP. We are now discussing which of two methods is more suitable to solve the picture noise problem.

4.2.5 The Effects of Reduction of CO_2 Emissions

This subsection evaluates the effect of utilization of HDTV conference systems with CISHDTV from the view point of the reduction of CO_2 emissions. As an evaluation example in the real world, we held “Training workshop of city worker”. The workshop was held with thirty members of Kurihara city office, and twenty-one members from Kannari branch office. In addition, two members from Hatsudai (Tokyo) also participated in the workshop as lecturers.

Table 4 shows the evaluation model and its assumptions. If all of the members gathers in a same conference room at Kurihara City office, twenty-one people from Kannari and two lecturers from Hatsudai have to visit Kurihara City office by automobile, subway and bullet train.

On the other hand, in the experiments, the members participated in the workshop with HDTV conference systems only needed to gather from their own offices. Figure 8 shows an overview of the workshop with HDTV conference systems. The XG80 (H.323 clients) in Hatsudai is connected to the MCU provided by CISHDTV beyond VPN. The HD-COMs (in NGN-SIP mode) in Kurihara and Kannari are connected to the MCU beyond NGN(HIKARI Denwa). Since the system in Hatsudai differs from the other systems, at least the lecturers have to go to Kurihara-city, if the CISHDTV is not

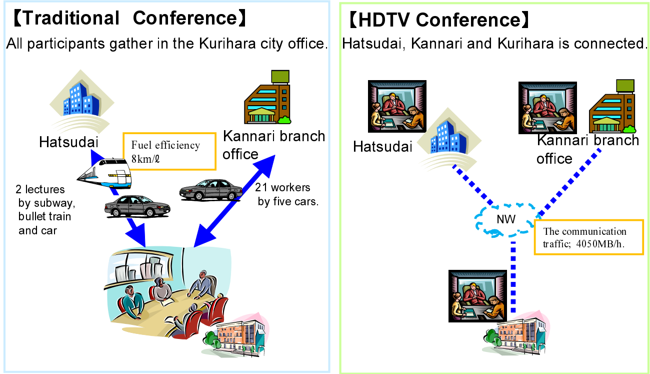

Figure 8: A training workshop for officers at the Kurihara-city with HDTV conference services.

Table 4: Evaluation model and its assumptions

	Traditional Conference	HDTV Conference
Common Conditions	[Participants] Kurihara:30, Kannari:21, Hatsudai:2, [Meeting Time] 90 min	
Evaluation Model	All participants go to the meeting room in Kurihara city office.	Interconnect Kurihara, Kannari and Hatsudai.
Assumptions	[Traveling by Train] -Participants from Hatsudai travel back and forth between Hatsudai and Kurikoma-Kogen station. [Traveling by Automobile] -Participants from Kannari travel between Kannari-SogoSisyo to Kurihara city office by six cars. -Participants from Hatsudai travel between Kurikoma-Kogen station to Kurihara city office by a car. -Automobile mileage: 11.2Km/L	[ICT System] -Conference on 90 minutes -Scheduled 72 hours/year -The distance from Kurihara to Kannari: 12km -Flet’s VPN Wide -Communication Traffic: 8GB/h

provided.

The reduction effect of CO_2 emissions are evaluated with *Kankyo Shiro* [28]. Kankyo Shiro is an evaluation system to measure environmental impacts. It measures how ICT services over networks can reduce the amount of CO_2 emissions quantitatively. In addition, it is fully compliant with the standardized guideline of Life Cycle Assessment Society of Japan Forum [29] under Ministry of Economy, Trade and Industry. Kankyo Shiro considers about every life cycle stage of ICT services, through its production, use and disposal. This system automatically displays the amount of CO_2 emissions by the entries concerned about ICT System, Soft-

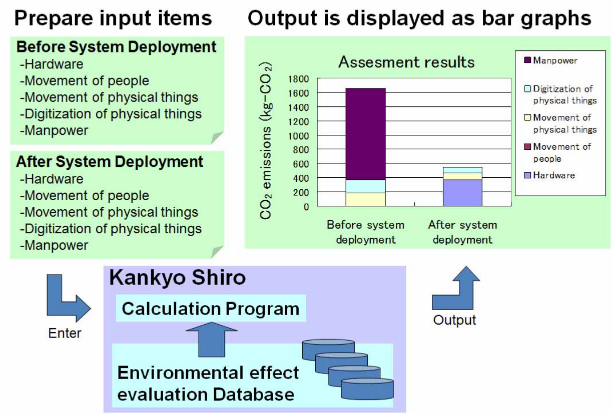

Figure 9: Flow of assessment by Kankyo Shiro.

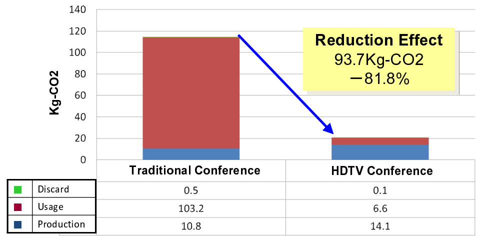

Figure 10: Reduction effect of CO_2 emissions.

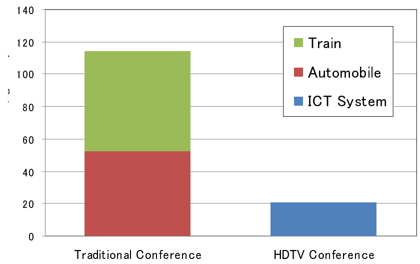

Figure 11: The factors of CO_2 emissions.

ware, Movement of People, Movement of Goods, Computerization, Transportation Efficiency and Behavior of people. It calculates the environmental load of the two cases, where ICT systems are introduced or not, and shows the effects of the case with ICT service compared with traditional method. A flow of assessment by Kankyo Shiro is shown in Fig. 9.

Figure 10 shows the reduction effect of CO_2 emissions in this experiment. From the result of the experimentation, it is calculated the amount of reduction of CO_2 emissions is about 93.7kg-CO_2. This is roughly equal to the mount of seven day's CO_2 emissions of average household [30]. As shown in Fig. 10, the reduction rate achieves about 80%, this is because the amount of CO_2 emissions caused by traffic movement exceeded that of by ICT systems.

Figure 11 shows the factors of CO_2 emissions in this experiment. The movement of the lecturers by train has occupied about 58% of total CO_2 emissions in the traditional conferences. In reality, train service is independent of the lecturers' action. However, Kankyo-Shiro takes account of the CO_2 emissions as a potential for reduction. Kankyo-Shiro calculates CO_2 emissions with the basic data, which is defined as a unit amount in which a person moves 1 kilometer by train. This is because that Kankyo-Shiro is based on a premise, that development and spread of IT technology will make people not to take trains and then reduce train services. Even if the movements by train do not take into account, we can see that the reduction of CO_2 emissions achieves about 40%.

In the experiments, the 21 officers of Kannari made a round trip to the Kurihara city office by five cars. The distance from Kannari to Kurihara is about 12 kilometers. From this condition, Kankyo Shiro calculates that the amount of CO_2 produced by the movement of car is about 40kg-CO_2. On the other hand, Kankyo Shiro also calculates that 17kg-CO_2 will be produced by the 21 officers' movement by train, if public railroad service is available between Kurihara and Kannari. Therefore, reduction effect of CO_2 emissions by HDTV conference system is more effective especially in the clustered-type city such as Kurihara, compared with metropolis with convenient public transportations.

5 Conclusions

This paper proposed a cloud-type interconnection service for heterogeneous HDTV clients, named CISHDTV, for the purpose of reduction of CO_2 emissions. Demonstration experiments in Kurihara-city show a service feasibility of CISHDTV. However, it still remains some problems, in which the messages instructing opposite-side client to refresh a picture could not reach to the opposite-side client, when the HDCOM client operates under the NGN-SIP mode. This causes a picture noise severely in the destination client. Now we are analyzing for the difference of implementation in detail, and discussing the proposed service in Multimedia SWG meeting of TTC [31] toward its standardization.

In addition, demonstration evaluations in Kurihara-city shows the effectiveness of proposed CISHDTV, especially it can achieve more than 80% reduction in CO_2 emissions. With a popularization of the CISHDTV, more companies or municipalities will be connected mutually through their existing HDTV conference systems. As a result, it will come to have a great effect on the reduction of CO_2 emissions.

In the near future, we expect that many organizations especially located around local city will utilize HDTV conference systems with CISHDTV.

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(Received March 1, 2012)
(Revised March 1, 2013)

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Application Push & Play – Proposal on Dynamic Execution Environment Combined with Personal Devices and Cloud Computing. -

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Abstract – Mobile devices have become essential tools in our life. To make effective use of a smartphone, a user may install many small applications and use them according to his/her circumstances. However, it is becoming impossible to ignore the time and effort a smartphone user spends to discover and install appropriate applications. In this paper, we propose a concept wherein desirable applications and data automatically descend from the Cloud and are executed on a device when a user is authorized to receive a service. Such applications are available only at the right moment and go away when a user no longer requires them. As a proof of concept, we implemented the system on an Android smartphone and confirmed that it can reduce installation steps and has a good enough response. The proposed system would be able to help users in their daily activities and provide a new user experience different from the conventional one.

Keywords: Mobile device, Cloud computing, Push services, Android

1 INTRODUCTION

A variety of personal devices such as smartphones, tablets, and personal computers are now on the market. In addition, there are many applications for such devices.

In terms of the usability, it is not necessarily easy to start using smartphone applications. The initial setup can be especially troublesome and annoying. For example, those who have purchased a smartphone tend to spend a long time finding and installing applications from an app store, etc., even from stores they frequently visit. Moreover, smartphones without any preinstalled applications would not be able to be used conveniently. Users hence have to find and install applications before use their phones. In addition, installing too many applications on local devices makes them inconvenient because it would be difficult to identify an application they want to use on the small screen of a smartphone. In short, people do not like to spend too much time setting up a smart phone because it has a short life cycle. It would thus be good to have a system where a user can receive services with minimal preparation.

There are several studies about usage of smartphone applications. Some point out that users use these applications as important tools to manage information, tasks, work, and social relationships in their busy lives. Time management is one of the most important factors for them.

According to the report of the SBE Council [7], mobile application discovery is a big problem for smartphone users.

Moreover, there are several studies showing that the retention rate of mobile applications is rather low. The Ringcentral Survey [6] found that the retention rate after six months is only 36%. Scott Kveton, CEO of Urban Airship, a mobile notifications provider, stated that there is only a 5% retention rate of free applications after 30 days.

Therefore, it is not always true that smartphone users can save time by utilizing mobile applications because they waste too much time in preparing seldom-used applications. In other words, reducing the time for discovery and installation of applications would give them a better mobile experience.

In this paper, we propose a concept of dynamic installation and execution called Application Push & Play (APnP) to resolve the above problem. In addition, we propose an architecture for a smartphone to embody the concept. We prototyped an APnP system by utilizing web applications executable on local devices and an Android smartphone. We used the results of the experiment to evaluate the feasibility and efficacy of our architecture.

2 RELATED WORK

Apple Inc. provides the App Store on iTunes [4] to distribute applications for iPhones. An iPhone user can download applications via iTunes on a PC, and synchronize and install them on an iPhone through a USB connection. A user can also download and install applications directly on an iPhone. Google Inc. provides the Android Market [3] for Android smartphones. The advantage of the Android Market is that a user can download and install applications from a PC to any android smartphone he/she owns. On the other hand, Apple has recently started to provide iCloud to synchronize all applications between devices. The problem is that Google and Apple do not care when and what applications a user wants to use though they provide a mechanism which delivers applications. In addition dedicated ids such as Google account and Apple id are required for a user to get application. It might be preferable for business purpose because some company policies does not allow to use such kind of ids in order to avoid the risk of information leakage.

In terms of applications for mobile devices, Jason Grigsby [5] compared three types of application: Native, Web, and Hybrid. 'Hybrid applications' are executable on local devices and are written in HTML, CSS and JavaScript. Though they look like web applications, they can run in a dedicated runtime environment on a local device. As far as Web applications go, HTML5 [1] specifies a disk cache that can let web applications run on a local device even when the network is disconnected.

MIT Project Oxygen [9] is a project that addressed challenges to support highly dynamic and varied human activities. The goal of Oxygen system is to help us do what we want when we want to do it using embedded devices, handheld devices, dynamic self-configuring networks and software that adapts to changes in the environment or in user requirements. The architecture relies on control and planning abstractions that provide mechanisms for change, on specifications that support putting these mechanisms to use, and on persistent object stores with transactional semantics to provide operational support for change. For example, it realizes that when a user having listened his favorite music in his room moves to living room, it automatically continue the music from the speaker in the room. The focus of this project is maintaining continuity of services by involving various available resources. On the other hands, our approach improves user experience by narrowing down of service delivery.

3 PROPOSED ARCHITECTURE

As described in the introduction, a big issue is how to reduce the time for discovery and installation of applications. Additionally, we believe this discovery and installation should proceed without user operations in order to save time and labor. In this section, we define the requirements and describe the architecture to enable this.

3.1 Requirements

The requirements are as follows:

(R1) Applications exist on a personal device only when a user needs them.
(R2) A user need not explicitly install/uninstall applications.
(R3) A set of suitable applications is automatically identified by a user's context.

The best way to resolve the issue of application discovery and installation is that a user does not have to think about it. All user wants to do is to deal with content; that is, s/he may not want to worry what kind of application can operate on the content. Thus, the requirement is that not the user but the system should identify applications which the user needs and can deliver them to a personal device just in time. (R3) is equivalent to the requirement of identification. The requirement of delivery is a combination of adequate notification (R1) and automatic installation (R2).

3.2 Architecture

Figure **1** illustrates the architecture of Application Push & Play in order to fulfill the above requirements.

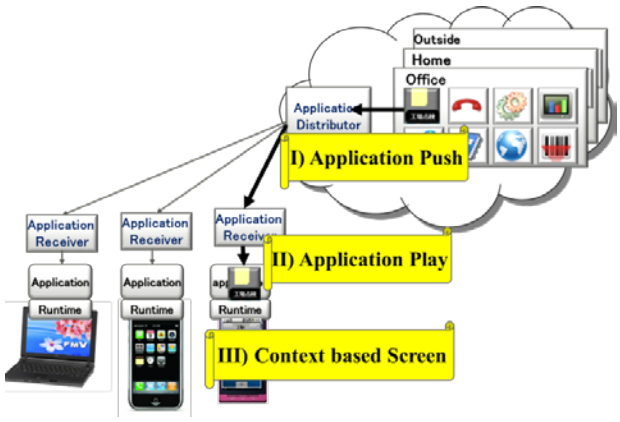

Figure 1: Architecture of APnP

The architecture consists of the following features:

(A1) Application Push
(A2) Application Play
(A3) Context-based Screen

Our approach assumes that all applications are in the Cloud environment and are downloadable and executable on local devices whether network connections are available or not.

'Application Push' (A1) handles distribution of applications and data based on a user's context determined from sensor information, user behaviors, etc. Once the system has detected a user's state as being likely to use a service, a particular application in the Cloud would be injected into the local storage of the user's device.

'Application Play' (A2) deals with automatic installation and execution of applications injected by 'Application Push'.

'Context-based Screen' (A3) provides a user with a simple and comprehensible GUI. It is a dynamically morphing home screen in accordance with the place and time of the user.

To meet requirement (R1), the system should have a method of real-time notification to deliver an application in a timely manner. In general, there are two methods of notification: "polling" and "push". In polling, a client checks a server periodically to see if there is an event. A typical example is an e-mail system in a PC. The push method is that a server notifies a client when an event occurs. A typical example is the SMS system in a cell phone. In terms of power consumption, the polling method is not as good for a smartphone. That is why the push notification of application (A1) is an important feature. Our architecture includes a server and push handler as a client.

To meet requirement (R2), the system should have a method of automatic installation (A2). This method includes a management functionality for downloading, storing data, and launching applications based on commands in a pushed message.

To meet requirement (R3), the system should have a method for a user to reach an application identified at a glance under a particular context. At a client-side's point of view, a user-friendly interface as a home screen optimized by context (A3) is important. In addition, the definition of the user's context is also important. There has been a lot of works about it, and many people are still considering what is the best way. The performance of our architecture extremely depends on which method is applied to. Therefore, it might not be practical even if we measured the performance in a particular method. In this paper, we address how stable the performance of our architecture except context identification. The mechanism for determining it can be placed in the Cloud, and it can collect information such as sensor data about a user. A simple example of a context engine is a location-based or schedule-based system. Typically, a task server includes a context engine and invokes notification via a push server.

Figure 2 shows the APnP Framework which presents the relationship between the three layers and the components described above.

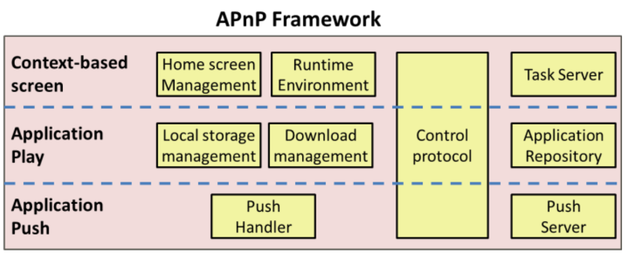

Figure 2: APnP Framework

4 PROTOTYPE IMPLEMENTATION

Figure 3 shows a prototype system to prove the feasibility of our architecture.

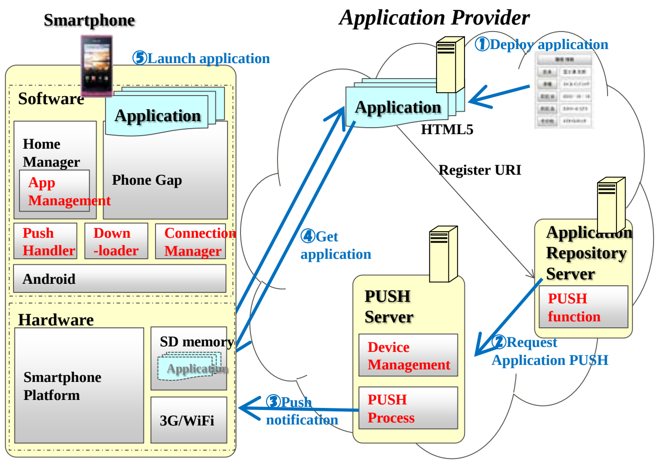

Figure 3: Implementation of the proposed system

4.1 Components

The system consists of the following components:

'Application Repository Server': This stores universal resource indicators (URIs) of applications. It picks up an appropriate URI upon an order from the 'Task Manager,' and commands the 'Push Server' to send a PUSH message with the URI.

'Application Provider': This stores an actual application and provides an interface to send it upon request.

'Task Management': This manages the user's context on the basis of calculating data from sensor information. Once it evaluates the timing to send a particular application to a particular user, it issues a command to the 'Application Repository Server' to send the application.

'Push Server': This constructs PUSH messages and sends them to client devices. Upon receiving a command from the 'Application Repository Server' it chooses an appropriate client device to send a PUSH message to with an application URI. Google already uses the PUSH mechanism in its Android Cloud Device Messaging Framework [2]. However, it is not suitable for business users because it requires a Google Account. Therefore, we implemented a dedicated PUSH Framework.

'Push Handler': This is a background process working on a client device to receive a PUSH message from a 'Push Server'. It keeps a TCP connection to 'Push Server' and can communicate with the 'Push Server' as long as physical network connectivity through 3G or WiFi is maintained. Once it receives a PUSH message and it finds an APnP command in the message, it hands the command to the 'Home Manager'. In this implementation, the 'Push Handler' is realized as an android application.

'Downloader': This is a client module to download applications from the 'Application Provider' to SD memory in the smartphone upon request from the 'Home Manager'. In this implementation, the 'Downloader' is realized as a library module included in the 'Home Manager'.

'Home Manager': This displays a home screen. It has three functionalities. First, it is an application launcher to execute applications. Second, it performs management of icons to be shown on the home screen. The home screen is dynamically changeable on the basis of APnP commands from the 'Push Handler'. It displays only icons necessary in context to provide a simple user interface. Finally, it orders the 'Downloader' to download applications. In this implementation, the 'Home Manager' is realized as an Android application.

'PhoneGap' [8]: This is a runtime environment to execute applications stored in SD memory in the smartphone.

4.2 Work flow

A typical work flow is as follows:

1. Deploy applications
   Developers distribute their packaged applications via an application server provided by an application provider. After that, they register the URI of the application with the application repository server. IT administrators might have to supervise this step for enterprise usage.
2. Request Application Push

Once the context engine, which knows the user's behavior, detects an event in which the user wants to use the application, it creates a command message and requests the push server to a notify the target device via.

3. Push notification
After receiving the request from the application repository server, the push server sends a push message which includes an APnP command to download and invoke the application.
4. Get application
When the push handler inside the smartphone receives the pushed message, it analyzes the APnP command and downloads zipped resources of the application by utilizing the HTTP protocol. After completing the download, it stores them in the SD card which is accessible to the home manager and PhoneGap.
5. Launch application
Finally, the downloader sends the Intent to the home manager to tell it that the download is complete. The home manager changes the screen and launches the application by invoking PhoneGap.

4.3 APnP Commands

APnP commands in a push message consist of the following elements:

Table 1: List of APnP Commands

Command Name	Description
APCTL	Operations of the Downloader, such as download an application, update part of an application, delete an application, etc.
HMCTL	Operations of the Home Manager, which displays options on how it shows notifications to a user.
HMOP	Option values which the Home Manager use, such as context information, delay period before executing an application, etc.
URI	The URI of applications.
RESOUCES	The resource name of the application to be downloaded.

4.4 Packaged application

An application is packaged as a set of resource files, a list of resources, and a manifest file.

Figure 4 is an example of a list of resource files. All files are described in plain text.

```
Index.html
pageA.html
pageB.html
webapp-manifest.json
walkingApp.manifest
images/walking.png
images/title.jpg
```

Figure 4: Example of a list of resource files.

In this example, HTML files ('*.html') and image files ('walking.png', 'title.jpg') are the actual content of the web application. The set of files constitutes the minimum resources in a common web application. Additional resources specific to this system are the 'walkingApp.manifest' and 'webapp-manifest.json'. The 'walkingApp.manifest' is the name of this file. It is specified in HTML5 [1] as a means of local execution. The resources described in this file are cached in local storage and can be executed without communication to a web server. The'webapp-manifest.json' is a manifest file to describe the properties of the application. Figure 5 is an example of 'webapp-manifest.json'.

```
{
  "appURI":
"http://www.example.com/walkingApp/",
  "appName": "walking",
  "description": "This application recommends a
good walking place."
   "creator": "fujitsu_healthcare@example.com",
  "version": "1.0 ",
  "manifest": "walkingApp.manifest",
  "icon": "images/walking.png ",
  "toppage": "index.html"
}
```

Figure 5: Example of a manifest file.

An application package is uniquely identified by an 'appURI'. The Downloader refers to the appURL to download the application and deploys the downloaded files in the local storage in the same folder tree. For example, files downloaded from http://www.example.com/ walkingApp/ are placed in /sdcard/apps/www.example.com /walkingApp/.

'appName' is the name of the application. 'description' is a detailed explanation of the application. 'creator' is the contact address of the developer. 'version' is the version number of the application. 'manifest' is the name of the HTML5 manifest file. The Downloader can get information about where each resource is located. 'icon' is an image file to show an icon on the home screen. 'toppage' is the entry page to be displayed first after launching the application.

5 EVALUATION

5.1 System evaluation

To evaluate the feasibility of the proposed system, each component shown in Section 4 was implemented in the following hardware:

Fujitsu PRIMERGY TX100: This was used an IA server to run the Application Repository Server, PUSH Server and Applications. It had an Intel Xeon Processor (E3120 3.16 GHz), 8GB DDR2 memory, 1TB SATA HDD, and 1000Base-T for NIC. The operating system was Cent OS 5.5

Smartphone T: This was a smartphone equipped with Android 2.1 to run client-side modules, such as Push Handler, Downloader, Home Manager, and PhoneGap, as a runtime environment.

Smartphone N: This was a smartphone equipped with Android 2.3.

Figure 6 shows an example screen transition.

The home screen provides a user-friendly interface to use application. The screen is switched based on user's context and displays limited icons for each screen even though a user installed a lot of applications. It should be a good navigation by giving a user limited choice to do in a particular context.

Home screen for outside.

Notification of an business application in the meeting room.

Execution of the application.

Figure 6: Example of Context-based Home Screen

The picture on the left is a snapshot of the home screen. In this example, it displays only icons suitable to outside when a user stays out. Example of context is outside, home, work, etc.

The picture in the middle is a snapshot of a notification that a business application is in a meeting room. In this case, the home screen changes from "Outside" to "Meeting room" as soon as the user comes into the company's meeting room. After that, a new icon of the application appears in the center of the screen, and a small icon is deployed on the home screen. It is optional to display icons on the home screen without invocations of an application.

The picture on the right is a snapshot of running the notified application. After notification, the system automatically executes the application without the user having to perform an operation.

After the user stops using the application, it might disappear from the device if the user no longer needs it.

It provides a simple user interface to a user and helps to discover application icons in the particular context.

5.2 Performance evaluation

5.2.1. Test Environment

To improve the user experience, the period from when a user notices a notification till when he/she starts to operate is very important. The time from receiving the PUSH message till the icon appears or till the application is invoked may be a bottleneck to providing the user a sufficient response rate. Therefore, we evaluated the difference in performance for four kinds of implementations on smartphones T and N. The specifications of each smartphone are shown in Table 2.

Table 2: Specifications of smartphone T and N

Model	Smartphone T	Smartphone N
CPU	QSD8250 1GHz	S5PC110 1GHz
Internal Memory	512MB RAM	16GB iNAND
External Memory	2GB Micro SD	Use a partition of internal memory
OS	Android 2.1	Android 2.3

Four kinds of implementation are determined by the combination of how to download and store an application and whether the application is compressed or not. The differences between the implementations are as follows:

I) Download a zip-compressed file and store it in SD memory. After that, unzip it and store the unzipped files.

II) Download a zip-compressed file and store the unzipped files in SD memory by utilizing ZipInputStream class without storing the zipped file.

III) Download an uncompressed file packed by using a tar tool and store it in SD memory. After that, unpack it and store the unpacked files.

IV) Download the uncompressed file packed by tar and store the unpacked files in SD memory by utilizing the TarInputStream class without storing the packed file.

At this point, we can make the following hypothesis:

<u>Hypothesis</u>:
The best method to reduce the delay is that an application package is compressed and is stored it directly as unzipped files in local storage.

To prove the hypothesis, we should confirm the following:

A) Total throughputs in Case-II and Case-IV are higher than in Case-I and Case-III, respectively.

B) Total throughputs in Case-I and Case-II are higher than in Case-III and Case-IV, respectively.

It is expected that (A) and (B) is true if the CPU is sufficiently fast. The reason why (A) should be true is because two times the file I/O operations occur in Case-I and Case-

III, in comparison with Case-II and Case-IV. The reason why (B) should be true is because the increase in data traffic has a large impact on the total performance in comparison with a reduction in the load of decompression process.

We measured the actual time spent from the beginning of downloading till the end of storing an application package for each case. In Case-I and Case-III, we also measured the download time and unpacking (or decompressing) time. The sum of both times is the total time.

The application package to be downloaded was a 167KB file containing 25 zip-compressed files in 5 folders, the re-write is a guess. The original is unclear.>. The total size before compression was 655KB. The compression rate was 27%. The application was downloaded through a WiFi connection.

5.2.2. Test results

Table 3 shows the results of the measurement. Each time in Table 3 is the average of 10 measurements.

Table 3: Measured results

Item #	Device	Case #	Total time (msec)	Down-load time (msec)	Un-pack time (msec)
N-I	N	I	203.2	110.2	93
N-II	N	II	190.8	-	-
N-III	N	III	434.4	264.6	169.8
N-IV	N	IV	402	-	-
T-I	T	I	817.6	197.9	619.7
T-II	T	II	653	-	-
T-III	T	III	1318.6	524.6	794
T-IV	T	IV	861.4	-	-

Figure **7** compares the elapsed times for each test case.

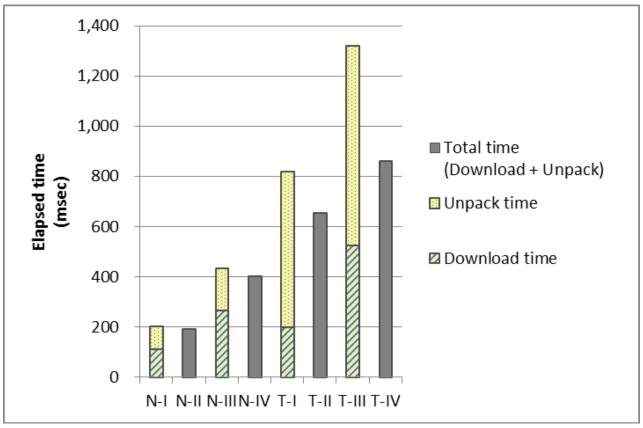

Figure 7: Comparison of the elapsed times.

Figure 8 compares the throughputs calculated from the results in Table 3.

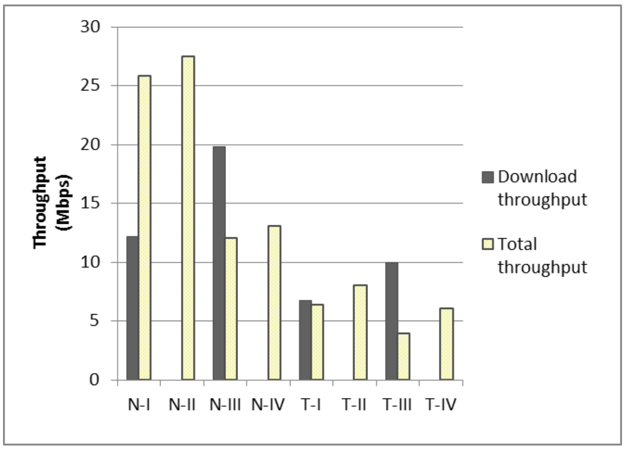

Figure 8: Comparison of throughputs.

5.2.3. Discussion on experimental results

The histograms reveal the following facts:

i). Smartphone N is approximately twice as fast as smartphone T in all cases.
ii). The fastest implementation is Case-II on both smartphones.
iii). There is little difference in time between Case-I and Case-II or between Case-III and Case-IV on smartphone N, whereas there is a significant difference on smartphone T.
iv). On smartphone N, the cases of using a compressed application package (Case-I and Case-II) are approximately two times faster than cases without compression of the application package (Case-III and Case-IV), whereas on smartphone T, there is little difference in total throughput between Case-I and in Case-IV.

The reason why smartphone N is faster than smartphone T is due to their different storage devices. The application is stored in external memory. The Micro SD memory used in smartphone T is significantly slower than the NAND flash memory used in smartphone N. Therefore, the difference in I/O performance has a large impact on total throughput. Fact-iv is due to the same reason.

Even the throughput of downloading on smartphone N is faster than on smartphone T. This result is presumably due to the difference in OS version. Android 2.3 is faster than Android 2.1 because it has the JIT (Just-In-Compiler). However, smartphone T has enough throughput because even the worst total time is less than a second if the application is zip-compressed.

In addition, the results of the cases without compression of application package were worse than expected. It is natural that data traffic is increasing, and download time is consequently increasing. However, there was difference between the unpack operations and there was supposed to be little difference between them because the performance of TarInputStream class on Android was poor. Hence, an application package should be compressed.

To summarize, the experimental results satisfied conditions (A) and (B) described in 5.2.1. Therefore, we were able to confirm that the hypothesis in 5.2.1 is true. In addition, it took less than 1 second even in the worst case using a compressed package in smartphone T. A user would rarely be able to notice the delay. The proposed method can be used for delivering applications since the performance of smartphones will improve in the future.

The results of the experiment utilizing an actual business web application confirmed that the smartphone was notified of the application's delivery within a few seconds after an event was issued, and that an application icon was dynamically added to the home screen, and the application was invoked shortly after.

6 USE CASE

In this section, we present an effective use case of an APnP system.

To simplify the user interface further, the home screen could be removed. That is, an application could be directly executed without displaying the home screen once it is distributed to our devices.

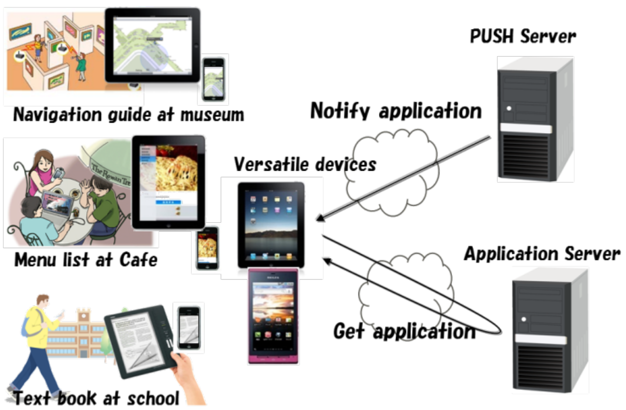

Figure 9: Example of service.

Figure **9** shows an example service. A user's device can be transformed into a textbook while he/she is at school. While he/she is in a museum, it can be a navigational guide. In such cases, a personal device with our system can behave as if it were a dedicated device and provide the user with a rather simple interface. Such a functionality might be more useful for a tablet device than for a smartphone.

7 CONCLUSION

We proposed the concept of APnP and prototyped a system where appropriate applications are automatically distributed and executed. Such applications are made available only at the right moment and disappear when a user no longer requires them. We confirmed that APnP can reduce the installation steps and has a sufficient response. In conclusion, APnP can help a user in his/her daily activities and provide a new user experience different from the conventional one.

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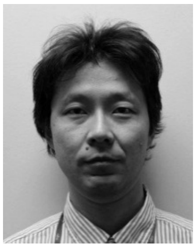
(Received February 27, 2012)
(Revised March 1, 2013)



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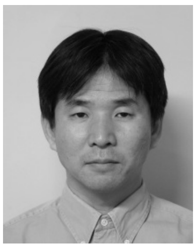

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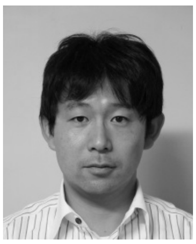

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An Effective Lookup Strategy for Recursive and Iterative Lookup on Hierarchical DHT

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Abstract - Recursive and iterative lookups on the performance of distributed hash table (DHT) are deteriorated by churn when nodes leave the network. When churn occurs infrequently, recursive lookup outperforms iterative lookup, but back when churn occurs frequently, the opposite is the case. Therefore, optimal lookup needs recursive and iterative lookups to be separated by the frequency of churn. We propose a lookup strategy that separates recursive and iterative lookups by the churn rate. However, a common DHT makes it difficult establish the neighboring churn rate. Hierarchical DHT takes into consideration the reliability of nodes to ascertain the churn rate, but it uses only a lookup strategy, recursive or iterative in the DHT. We believe that each lookup strategy should be used that match the churn rate in hierarchical DHT. Therefore, we compared our lookup strategy with both recursive and iterative lookup on hierarchical DHT.

Keywords: Recursive lookup, Iterative lookup, Hierarchical DHT

1 INTRODUCTION

Peer-to-Peer (P2P) is communication in which each node is equal and various values are dispersed throughout the network. Therefore, distributed hash table (DHT) is an efficient lookup technology in P2P. DHT can discover values with low numbers of hops in large networks. Examples of DHT-based P2P include Chord[1], Kademlia[2], and Pastry[3]. Even if DHT uses the same algorithm as Chord or has routes on the same lookup path, their communication methods are defined differently. Its methods are known to be recursive and iterative lookups[4]. These lookups have different lookup latencies and numbers of messages. Recursive lookup, which has low latency, is generally satisfactory. However, the performance of these lookups deteriorates due to churn where nodes leave the network. In addition, recursive lookup performs worse than iterative lookup. Therefore, optimal lookup needs recursive and iterative lookups to be separated by the system churn rate. However, flat normal DHT it is not structured to consider the feature of nodes, e.g. the churn of nodes. For this reason, it is difficult to establish the system churn rate.

There is a structure called hierarchical DHT[8][9] that enables DHT to be used efficiently. This structure can separate a number of clusters depending on needs. A hierarchical DHT has been developed with advanced features that take into consideration how reliable nodes are[10]. This has a clustering method that establishes the reliability of nodes. Thus, the reliability of each cluster is approximately established.

We propose applying an optimal lookup strategy to each cluster on hierarchical DHT that considers the reliability of nodes and separates recursive and iterative lookups efficiently.

2 RELATED WORK

2.1 Chord

Chord is a DHT algorithm that takes into consideration the hash space as a space like a ring and sets nodes an identifier called the node ID with the hash function. Keys are calculated similarly with this function. Of the nodes arriving in a network, the node just behind a node is called a successor node, and the one just before a node is called a predecessor node. Nodes keep the neighbor as a successor list that has a number of successor nodes and a finger table that can route efficiently to the routing table. Chord completes lookup with path length $O(\log N)$ when N is the number of all nodes. The state of these nodes is the previous state obtained by churn and failure. For this reason, Chord is implemented as a stabilization process to accurately retain the state of neighbor nodes. This is a process where nodes ask nodes in the routing table. In addition, it is executed at regular intervals.

2.2 Lookup strategy

Recursive lookup is a lookup method that uses an originator node that demands value requests lookup other nodes. However, iterative lookup is where the originator controls lookup to ask other nodes about candidates for the next hop. Figure 1 outlines the shape of each lookup on Chord when there are three hops (path length).

The originator in recursive lookup forwards a request message to a node that is closer to the destination (Figure 1 (1)). If a node in the next phase receiving a request message does not have the value that is purposed, it forwards the request message to a node that is closer to the destination than itself. This process is executed until the request message reaches the destination node (Fig. 1 (2), (3)). In contrast, the originator in iterative lookup receives a reply message to a request message after the message has been forwarded (Fig. 1 (1-2), (2-2)).

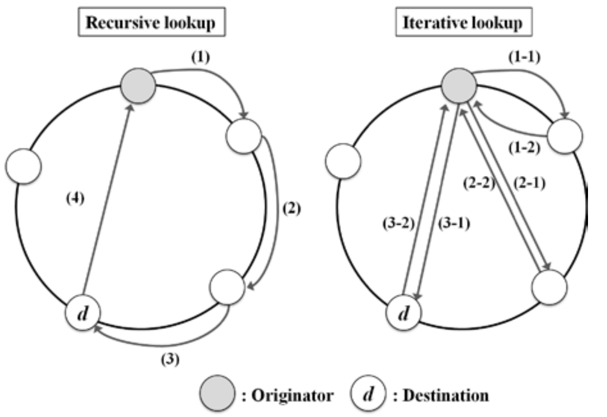

Figure 1: Recursive and iterative lookup strategy on Chord when path length = 3.

When a node that receives a request message does not have the value that is purposed, the reply message includes the addresses of nodes that are closer to the destination than itself. The originator forwards a request message to the destination node by using the address included in the reply message.

The performance of recursive and iterative lookups is affected in accordance with this communication method and churn where nodes leave the network. The system churn rate, which is the probability of which nodes on the network will leave the network determines the life-time of nodes. R is the defined life-time of a node and refers to the reliability of nodes. R varies between nodes. The cumulative distribution function[5] of exponential or Pareto distribution[6] is used as a function to define R. R makes known how often churn occurs in the system. S is defined as the time until nodes detect failure and repair the routing table of the node when churn or failure occurs. For this reason, S just means the interval in which the stabilization process is executed. Altogether, large S means that the stabilization process is seldom executed, but small S means that stabilization is executed often.

We also assumed that $E[R]$ and $E[S]$ were value expected for the R and S of neighbor nodes for a node. By using these parameters, p is defined as the probability of which next hop candidate node is alive in the network and the success of forwarding a request message, which is given by the following[7].

$$p = \frac{E[R]}{E[R] + E[S]} \tag{1}$$

When neighbor nodes are in a steady state when starting lookup and the originator is not executed to repair its own routing table, $E[S]$ approximates a fixed value. As a result, p depends on $E[R]$. In addition, large $E[R]$ means that neighbor nodes are alive for a long time, and this also means that churn is not likely to occur. In contrast, small $E[R]$ means that churn often occurs in neighbor nodes that have shorter life-times. That is, the churn rate is low when p is high and high when p is low. More specifically, p becomes a value that means the churn rate in the network when $E[S]$ approximates a fixed value.

The performance of recursive and iterative lookups are defined[7] by using churn rate p and latency of communication. First, we assume that the lookup path length is l and t is the latency for one hop. We also assume that physical links between nodes are not considered, and t is fixed. In addition, T is the time, which is timeout when nodes fail to forward messages by churn or failure. Here, timeout T is configured differently at each lookup. The originator in recursive lookup has to wait for responses to complete as lookup is completed. However, other nodes only forward request messages to the next hop node and are not concerned with the forwarded message. Therefore, T in recursive lookup is set to no less than the time to complete the entire lookup at only the originator. For this reason, T_r as the timeout in recursive lookup is configured as $T_r \geq (l+1)t$. The originator in iterative lookup similarly waits for a response from the next hop node point by point. Therefore, timeout is configured to no less than the time to wait for forward and reply. Consequently, T_i is the timeout in iterative lookup set by $T_i \geq 2\,t$. As a result, the expected latency of recursive lookup $E[RL]$ is defined in the following by these parameters.

$$E[RL] = (l+1)\,t + \frac{1-p^l}{p^l} T_r \tag{2}$$

The expected latency of iterative lookup $E[IL]$ is also defined in the following.

$$E[IL] = 2lt + \frac{1-p}{p} l T_i \tag{3}$$

In both recursive and iterative lookups, when l and t are fixed, p has a profound effect on performance. Figure 2 shows that an example of all expected latencies under different p when l and t are fixed values.

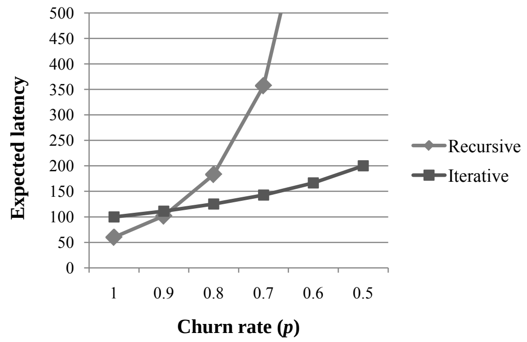

Figure 2: Expected latencies of recursive and iterative lookups under different p.

Moreover, T_r is much higher than T_i with this timeout setting. Thus, by using formula (2), the expected latency of recursive lookup increases especially when p is low. When p is low, on the other hand, iterative lookup does not have such high latency. However, when p is high, e.g. $p = 1$, this is higher than that of recursive lookup. Therefore, to improve the performance of recursive and iterative lookups, we need to determine the system churn rate.

2.3 Hierarchical DHT

Hierarchical DHT is a structure that divides a logical network configuration created by the DHT algorithm[8][9]. Figure 3 shows an example of a hierarchical DHT with two tiers in the Chord algorithm. Divided networks are called top- and lower-level clusters. A top-level cluster is built by particular nodes called super nodes. Super nodes generally adopt strong nodes in the network, e.g., those with a great deal of high storage and high processing capacities that have been alive in the network for a long time, or those with wide bandwidth. Other normal nodes and a specific super node belong to the lower-level cluster. The super node provides normal nodes with routes to other clusters.

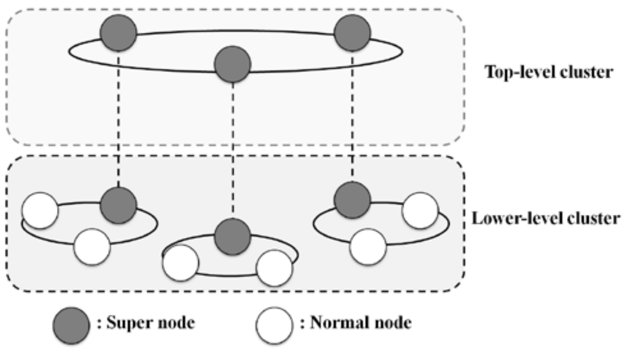

Figure 3: Example of two-tier hierarchical DHT.

Hierarchical DHT can speculate clusters where the destination of lookup belongs by comparing high m bits between the key and node ID. This m means the number of clusters in the hierarchical DHT by 2^m. When the high m bits of the key and a node ID are the same, the node forwards in the cluster. Otherwise, the node asks the super node of the cluster to forward, and the super node finds the destination cluster and super node address by using the key.

Hierarchical DHT has various features, i.e., to assemble normal nodes for their purpose and confine the effect of churn locally for neighbor nodes. An advanced study of hierarchical DHT found it to take into account the reliability of nodes[10]. This determines low-level clusters where normal nodes belong by using the interval from when they join to when they leave. The interval time is assumed by using a function, and this means that it is equivalent to R as the life-time of a node. The function in this study assembled nodes that had similar R in each cluster. In addition, a super node was selected as a node that had the highest R in the cluster. Nodes are clusters obtained by R in this way in hierarchical DHT that considers reliability. Therefore, $E[R]$ becomes high due to clustering nodes that have higher R, and this also decreases by using clustering nodes that have lower R. Here, we assume that the interval for the stabilization process is fixed at all nodes and nodes obtain $E[S]$, which is almost a fixed value. p is defined as $E[R]$ in formula (1), and so this differs specifically for each cluster. Therefore, the p of each cluster can be speculated, and we can consider the optimal performance of a system that is appropriate to p.

3 GOAL AND APPROACH

When p is low in recursive and iterative lookups, recursive lookup has an advantage, but when p is high, iterative lookup has an advantage. We select which lookup to uses by using the churn rate. This ensured that the expected latency of lookups was the best under any churn rate. Our goal was to demonstrate this. To speculate churn rate p, we noted hierarchical DHT took reliability into account. Hierarchical DHT determines clusters in which p is high or low as a result of clustering by the R of nodes. We focused on a structure where p was different for each cluster. And we believe that lookup strategies may be used to match the p of clusters. However, the hierarchical DHT uses one of the lookup strategies. Furthermore, we must consider that each message format in recursive and iterative lookups is different.

Here, we propose a strategy that changes over from one lookup to another by transforming the format of messages. We will explain how this strategy optimizes performance more than when only recursive or iterative lookup is used.

4 PROPOSED METHOD

4.1 System model

We propose that each cluster separates recursive and iterative lookups on hierarchical DHT to consider reliability. We used the Chord algorithm because it had various features, e.g., it had a simple structure and was scalable. We also noted the stabilization process for the formula (3). Although super nodes were adopted in the clusters, we assumed that super nodes would be adopted in the system. This meant that the R of super nodes had no relationship with the R in the clusters. Here, the R of super nodes is R_s, and that of other normal nodes is R_n. Clusters in assembled nodes that have low R_n, called lower clusters, use iterative lookup in the clusters because they have low p. However, clusters in assembled nodes that have high R_n, called higher clusters, use recursive lookup. For example, a top-level cluster built by a super node has R_s. R_s is relatively high approximately R in the system. Therefore, a top-level cluster uses recursive lookup. There are recursive and iterative lookups in the system for this reason. Here, it transforms from recursive into iterative and vice versa depending on the message format. This process is executed at super nodes. This provides the communication between higher and lower clusters.

All nodes have a routing table built by the Chord algorithm to structure hierarchical DHT. For example, that of the normal node includes normal nodes that belong to the same cluster and super nodes of the cluster. Also, super nodes have routing tables that included normal nodes belonging to the cluster and the super nodes of the top-level cluster.

4.2 Transformed process

There are request and reply messages in recursive and iterative lookups. Each message format is different due to the lookup strategy. For example, a reply message including next hop candidates is used in iterative lookup as a routing table. However, no reply messages are used in recursive lookup. Tables 1 and 2 indicate that both request and reply messages have to include information at least in recursive and iterative lookups.

Table 1: Information in request message.

	Identifier	Key ID	Address of originator	TTL
Recursive	○	○	○	○
Iterative		○		

Table 2: Information in reply message.

	Identifier	Next hop Candidates
Recursive	○	
Iterative		○

Recursive lookup can forward in parallel because it trusts other nodes with forwarding request messages. Messages have to include the address of the originator, the message identifier that determines what value is received for which request message, and the Time To Live (TTL), which is always set to forward request messages. This includes the message identifier. In iterative lookup, on the other hand, request messages do not have to include the address of the originator, identifier, or TTL because the originator controls the lookup. It only includes the key ID. However, reply messages must have some next hop candidates. Forwarding cannot continue because request and reply messages in both lookups are missing some necessary information.

By considering these differences, we implemented a transformed message format and lookup strategy. This transformed process particularly executes the transform from recursive to iterative and vice versa. It needs to be executed at all nodes on a flat DHT that does not have a hierarchy. However, the extent of the lookup strategy on hierarchical DHT is localized by clustering. For this reason, the transformed process is only executed at super nodes, which are contact points between clusters. The super nodes are confined to belong to lower clusters. They provide normal nodes with forwarding to top-level cluster and other clusters. Also, they provide other super nodes with forwarding to lower clusters. The flow for this operation of super nodes is outlined in Fig. 4.

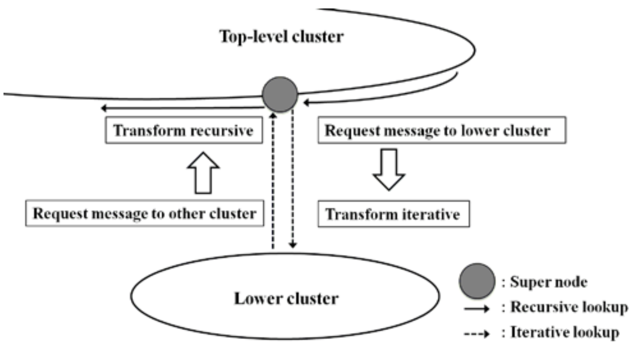

Figure 4: Transformed process at super node of Lower cluster.

When a super node receives a request message for iterative lookup from a normal node, if the destination is in another cluster, it creates a request message for recursive lookup from the subject matter of that message. However, the request message for iterative lookup does not include the identifier, the address of the originator, or TTL. For this reason, the super node creates a new identifier for the request message, and sets the TTL from the route. Also, the address of the originator is specified by the super node. Normal nodes do not read messages for recursive lookup because they do not transform from recursive into iterative message format. Therefore, super nodes provide the originator with a forwarding destination node and accept the reply message including the value with the transformed recursive into iterative message format.

However, when a super node belonging to a lower cluster receives a request message for recursive lookup, it can create a message for iterative lookup by only obtaining a key ID from the message. The value from the destination node similarly passes the super node, and the value of the transformed format is sent.

4.3 Lookup strategy

We propose that higher clusters use recursive lookup, and lower clusters use iterative lookup. Here, a top-level cluster is recognized as a higher cluster and uses recursive lookup. As a result, the pattern for lookup executed in the above transformed process is categorized as two patterns, (A) from the lower to the top-level cluster, and (B) from the higher to the lower cluster.

First, Fig. 5 shows an example of pattern (A).

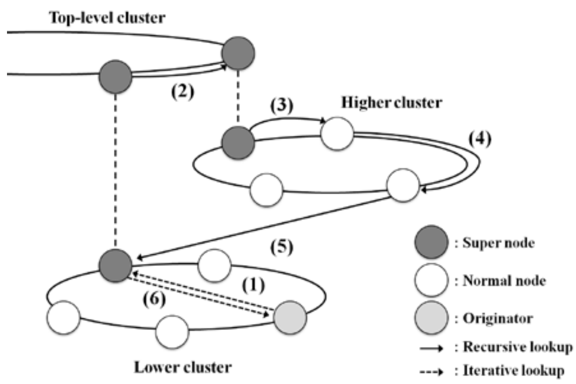

Figure 5: Lookup from lower to higher cluster.

The flow for lookup where request and reply messages are forwarded is indicated by the number in Fig. 5. In addition, request messages for iterative lookup are transformed into those for recursive lookup. First, the originator requests a super node to forward to another cluster with iterative lookup (Fig. 5 (1)). The super node transforms the message at the start, and starts recursive lookup. The lookup forwards to super and destination nodes (Fig. 5 (2)-(4)). Although the destination does not directly send the value to the originator, it sends the super node belonging to the originator (Fig. 5 (5)). The super node transforms the received message, and sends data to the originator (Fig. 5 (6)). We consider that this pattern shorten the latency of the entire lookup more than that with only iterative lookup because it uses recursive lookup at the part with low churn.

Second, Fig. 6 shows an example of pattern (B).

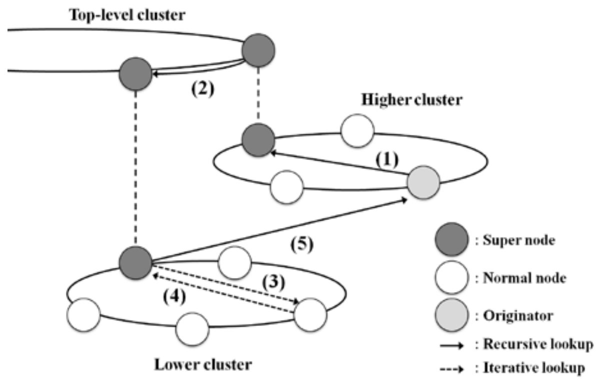

Figure 6: Lookup from higher to lower cluster.

A super node in this pattern executes the transformed process that creates a request message for iterative lookup from the request message for recursive lookup. Therefore, when the originator sends a request message for recursive lookup, lookup is executed at the super node of the destination cluster (Fig. 6 (1), (2)). The super node executes the transformed process, and forwards destination by using iterative lookup (Fig. 6 (3), (4)). The value is presented by using the communication shown in Fig. 6 (4). The super node sends a reply message including the value for recursive lookup to the originator (Fig. 6 (5)). Incidentally, the originator has to wait $2T_r$ because the lookup uses iterative lookup in the middle of lookup. By using iterative lookup at lower clusters where the churn rate is high, this pattern can shorten the latency of the entire lookup more than that with only recursive lookup.

5 EXPERIMENTS

5.1 Presupposition

We implemented the lookup in the Overlay Weaver[11] to evaluate our lookup strategy and compared its performance with that of only recursive or iterative lookup.

First, the setting for running the simulation and the version of the Overlay Weaver were:

- OS: Windows 7 Professional 64 bits
- CPU: Intel Core i5 3.2 GHz
- Memory: 4.0 GB
- Overlay Weaver: Ver. 0.10

Table 3 summarizes the parameters we set in the simulation.

Table 3: Parameters in simulation.

Number of nodes (N)	1000
Number clusters (C)	4
Latency of one hop (t)	6 ms
Recursive timeout (T_r)	84 ms
Iterative timeout (T_i)	15 ms

The number of nodes and clusters is defined by parameters in the work of Sato[10]. Sato's simulation used a Chord network by a minimum of 250 nodes. Although we set 250 nodes in a cluster, we have to discuss the number of clusters. C also means the number of super nodes, and C among N works as super nodes. Then, the lower-level cluster is built by other nodes as normal nodes. Therefore, a lower-level cluster has 250 nodes. Normal nodes have no relationship with the distribution of R, and there is not much difference between the numbers of nodes in each cluster. Thus, we assumed that latency t is 6 msec. This simplifies our simulation, so it does not consider a real environment. In actuality, t may be longer than this value.

Next, both timeout is set as a random value, so 84 and 15 ms mean maximum value. T_r is based on the definition expressed in Subsection 2.2. We assumed that path length l was defined as $O(\log N')$ when N' was N/C as the number of nodes in the lower-level clusters. Also, we considered that it had the lookup of top-level clusters and a potential of over $O(\log N')$, so we added various values to l. T_r is defined by multiplying t by l. Similarly, T_i is the value multiplying t by 2 and adding a slight allowance because a node has to wait for a response in iterative lookup. Therefore, T_r and T_i are defined formula (4), (5) when the various value is r. These timeouts are set for all nodes, but the originator does not wait for a timeout. If the originator uses iterative lookup, the lookup will soon end by a timeout. Thereby, originator has to wait for the response of the super node.

$$T_r = t\left[\log\left(\frac{N}{C}\right)+1+r\right] \qquad (4)$$

$$T_i = 2t + r \qquad (5)$$

Path length l is generally determined to be the key ID, which is a parameter that is not included in Table 3. This key ID is used the same as key ID to equalize the effect of l in all simulations as much as possible. By equalizing the effect, we ran the simulation for the key ID 100 times, and measured the average. In addition, we assumed that a higher and lower cluster were the same cluster in every simulation. We also assumed that churn rate p of higher clusters using recursive lookup was one at all times and p in lower clusters using iterative lookup could be set freely. According to formula (1), p means the churn rate and S needs to be nearly a fixed value. For this reason, nodes must not repair routing tables by churn during lookup. Additionally, the stabilization process was set to a large interval of 125 sec. This means $E[S]$ had a fixed value because nodes repaired fewer routing tables due to the stabilization process.

In addition, the following shows the routing tables of nodes.

- Predecessor node
- Successor List (no more than eight successor nodes)
- Finger table
- Normal nodes have super nodes in the cluster
- Super nodes have other super nodes in top-level cluster

When a normal node forwards a request message to another cluster, the node can forward the message to a super node in the same cluster in one hop. Additionally, a super node knows all other super nodes in the lookup for the top-level cluster and can forward the message to the super node of the destination cluster in one hop.

We considered lookup where a normal node forwards request messages to the node of another cluster. Additionally, there are three lookup patterns for a cluster, and each lookup is executed in different nodes.

We measured latency from higher to lower clusters and otherwise with each lookup strategy using the above parameters.

5.2 Results

We measured average latency with simulation. Here, we assumed that the latency was the time until the destination node received a request message. In addition, the time also included the internal processing time of each node. Therefore, it measured $E[RL]$ and $E[IL]$ as follows in this simulation.

$$E[RL] = lt + \frac{1-p^l}{p^l} T_r \qquad (4)$$

$$E[IL] = 2(l-1)t + \frac{1-p}{p} lT_i \qquad (5)$$

First, we will consider pattern (B) in Subsection 4.3, which is a lookup whose destination cluster is higher. It assumes that the p of the higher cluster and that of the super node that belongs to a lower cluster are set to one at all times. Also, the originator does not leave the network. Additionally, we assumed that there was one lower cluster and three higher clusters. Therefore, we measured the average latency of nine lookup patterns that forward request messages to higher clusters. The results obtained from simulation are presented in Fig. 7.

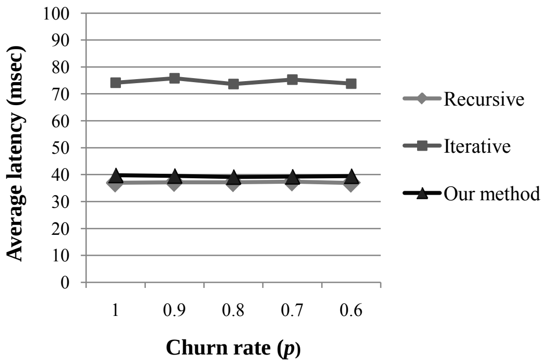

Figure 7: Average latency to three higher clusters by each lookup strategy.

This lookup pattern has little relevance to churn rate. The first address is the super node belonging at the cluster because this lookup pattern necessarily forwards a request message to other clusters. The super node forwards the request message to a super node belonging at the destination cluster. Each node assumes that churn does not occur. In addition, churn also does not occur after that because destination cluster is higher. As a result, the average latency barely changes at all under any p. In Fig. 7, when all nodes are steady state, the latency of our method is half that of iterative lookup. Our method has latency comparable to that of recursive lookup.

Second, we will consider pattern (A), which is the lookup from a higher to lower cluster. There are three lookup patterns from three other higher clusters. We set lower cluster to p, which is single value from 1 to 0.6. Also, we ran a simulation for each p 100 times and measured the average latency in each lookup strategy. The results are shown in Figure 8.

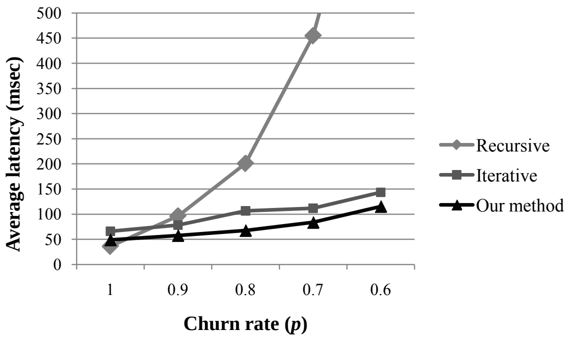

Figure 8: Average latency to one lower cluster by each lookup strategy.

If churn increases in Fig. 8, the average latency also increases. Recursive and iterative lookups are much the same as those in Fig. 1. However, our method performs the same as recursive lookup when p is one. If p decreases, increment of the average latency is similar to that of iterative lookup. Also, the results of our method are not identical to those of iterative lookup. Margin of average latency on each lookup is invariant from $p = 1$ to $p = 0.6$. Recursive lookup has the best average latency at only $p = 1$. However, from $p = 0.9$, recursive lookup has the worst average latency.

Here, we will think expected latency of this structure. This means the latency when any node forwards. Also, this has relevance to the structure. For example, the above simulation has one lower cluster and three higher clusters. If higher cluster is more than lower cluster, it is generally expected better latency. Because there is a high probability that the destination cluster is higher. On the other hand, if lower cluster is more than higher cluster, expected latency becomes low because it is a high probability that the destination cluster is lower.

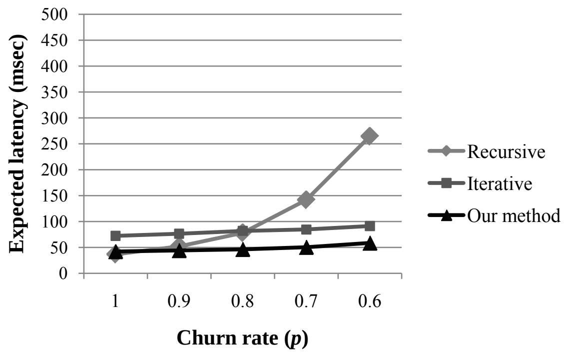

Figure 9: Expected latency on one lower cluster and three higher clusters.

For this reason, by using these results, we measured the average latency of the structure. This was measured by multiplying each of average latency when the destination cluster is both higher and lower by the number of higher or lower clusters. In this case, results in Fig. 7 are multiplied by three as the number of higher clusters and that in Fig. 8 by one as the number of lower clusters. Then, it measured the average of these results. We assumed that it is expected latency on the structure. Figure 9 shows the results in the case of one lower cluster and three higher clusters.

This hierarchical DHT is made mostly of higher clusters, and so the expected latency is better than average latency to lower clusters. Iterative lookup and our method have flat latency as well. Also, recursive lookup has better average latency than average latency of only lookup to lower clusters.

Here, we think about the relationship between the average latency and the number of each cluster. In above case, we show the average latency when the structure is one lower cluster and three higher clusters. We think that the average latency is influenced by the number of lower and higher clusters. Therefore, we considered simulations that have different numbers of these clusters within *C*.

First, we ran a simulation in which the structure has two lower clusters and two higher clusters. Each lower cluster is set the same *p*. In this case, we obtained six lookup patterns in which the destination cluster is lower. Also, there are six lookup patterns that destination cluster is higher. As shown in Fig. 7 and 8, we measured the average latency in each lookup pattern. Figure 10 and 11 show each of average latency for lower and higher clusters.

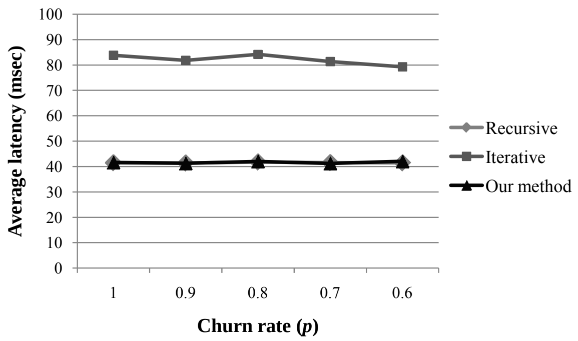

Figure 10: Average latency to two higher clusters by each lookup strategy.

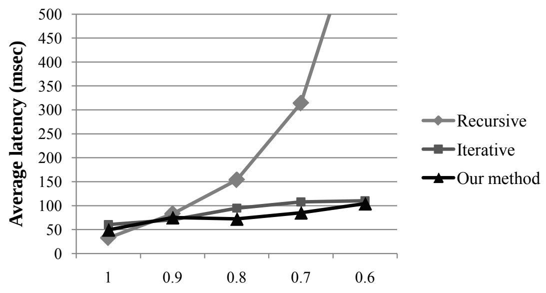

Figure 11: Average latency to two lower clusters by each lookup strategy.

These streams are not much more than Fig. 7 and Fig. 8. The result of Fig. 10 is a little higher than that of Fig. 7. Also, that of Fig. 11 becomes low a little. However, these results are evaluated relatively, and they mostly equal. We will discuss minor margin about their data on Section 6. Similarly, by these results, we measure expected latency of this structure. The result is shown Fig. 12.

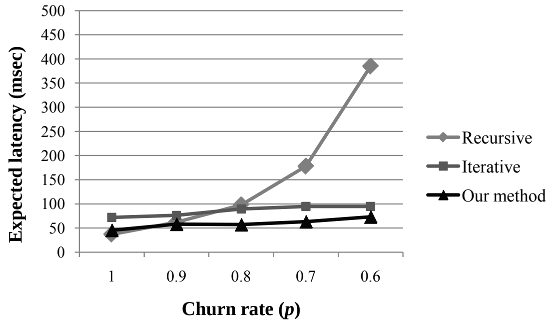

Figure 12: Expected latency on two lower clusters and two higher clusters.

This result is totally a little higher than result of Fig. 9. When *p* is 0.8, the result of Fig. 9 is that recursive lookup is lower than iterative lookup. However, Fig. 12 shows that recursive lookup is higher than iterative lookup under the churn rate.

Second, we ran simulation that structure has three lower clusters and one higher cluster. In this case, lookup patterns that destination cluster is higher are three patterns. There are nine lookup patterns that destination cluster is lower. We measured the average latency each lookup pattern similarly. The average latency of the pattern that destination cluster is higher is shown as Fig. 13. Also, we show the average latency to lower clusters in Fig. 14.

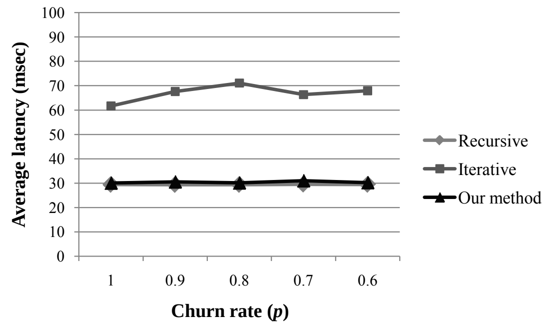

Figure 13: Average latency to one higher cluster by each lookup strategy.

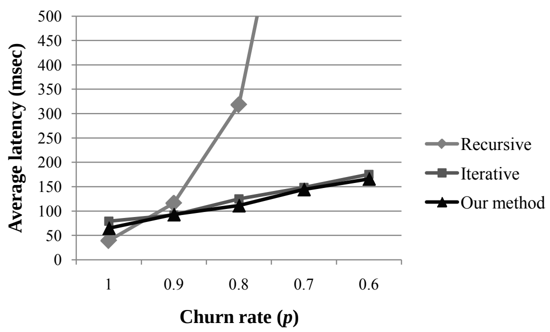

Figure 14: Average latency to three lower clusters by each lookup strategy.

These results have mostly the same stream. However, max value of average latency to lower clusters is higher than other results to lower cluster. On the other hand, max value of average latency to higher cluster is better than other results. Similarly, by these results, we measure expected latency of this structure, and the result is shown Fig. 15.

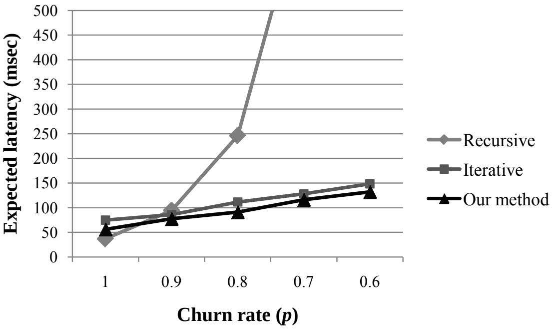

Figure 15: Expected latency on three lower clusters and one higher cluster.

These results are much higher than other results of expected latency. However, the stream of the results is not much more than those of other results. In addition, when p is 0.9, the expected latency of recursive lookup is a little higher than other lookup strategies.

According to these results, when nodes forward request messages to higher clusters, our method provides the performance of recursive lookup. Also, our method provided the performance of iterative lookup when nodes forward request messages to lower clusters. This is possible under any churn rate at lower clusters and proportions of higher to lower clusters. As a result, our method is effective when compared with only recursive or iterative lookup under any state and structure.

6 DISCUSSION

We will discuss the above results. First, we note the effect of our method. When the destination cluster is higher, our method performs similarly to recursive lookup under any churn rate and structures. Also, when destination cluster is lower, our method performs similarly to performance of iterative lookup under any situations. As a result, the expected latency of our method is relatively better than other lookup strategies as integrated evaluation.

Second, we note the average latency of lookup to higher cluster on each structure. For the average latency of each lookup strategy, although the rate is almost the same, the max value each of average latency is much different. This is considering that all lookup patterns have different path lengths. The path length is five at minimum and eleven at maximum. If the path is long, latency becomes high. Therefore, average latency becomes high in the patterns that have long path length. For this reason, the results in Fig. 10 include patterns that have long path length, and those in Fig. 13 do not. However, we can find the integrate effect of path length by measuring expected latency. If we consider the effect of churn rate, path length may have to be fixed.

In the results of expected latency, when higher cluster is defined as p = 0, if super nodes know the churn rate of each cluster and a number of clusters, we can evaluate effectively the lookup strategy under the churn rate. For example, if p of a cluster becomes 0.8, the cluster uses iterative lookup when there are already two clusters using recursive lookup and one cluster using iterative lookup. This is shown in Fig. 12.

However, the case in which p is 0 is less common in P2P. For this reason, we have to define higher and lower clusters. Therefore, we will research rigorous p, the structure of clusters, and the effects of different numbers of nodes and the clusters.

Finally, we attended to recursive + ACK lookup strategy. This lookup strategy has best expected latency among lookup strategies under any churn rate. $E[RL+ACK]$ is defined in the following, and Fig. 16 shows comparison of $E[RL+ACK]$ with $E[RL]$ and $E[IL]$ under different p.

$$E[RL + ACK] = (l + 1)t + \frac{1-p}{p} lT \tag{6}$$

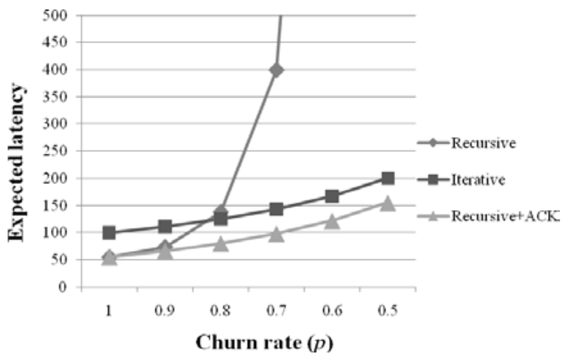

Figure 16: Expected latencies of recursive, iterative, and recursive + ACK lookups under different p.

Here, we had a question, why do not we use recursive + ACK in hierarchical DHT. Thereby we researched about advantage of iterative lookup. According to Ref.[12], iterative lookup has some advantages that recursive lookup lacks, fate-sharing, debugging, compartmentalization, and route table extraction. We think that these advantages are effective on mobile P2P environment where a lot of nodes abruptly disconnect P2P network. Because intermediate peers of mobile have probability of lost messages. However, for successful forwarding, it is important that high reliability nodes use iterative lookup, because it has fate-sharing. In our proposed method, super nodes use iterative lookup at lower clusters. So we think that our method is more reliable forwarding than recursive + ACK lookup strategy.

7 CONCLUSION

We noted the effect of churn for recursive and iterative lookups in this study, and there were differences in the churn rate for each cluster on hierarchical DHT when the reliability of nodes was considered. We proposed a lookup method that will leverage both lookup advantages by selecting relevant lookup strategy at each cluster. Additionally, we demonstrated that the new approach is significantly better in comparison to only recursive or iterative lookups. As a result, our method had the best expected latency under any churn rate. In future work, we need to consider an approach that dynamically applies our method to a DHT system. Additionally, we intend to propose an adaptive method that is able to adjust to variations in clusters by specifically defining the reliability of nodes and measuring the churn system. Also, we intend to consider various other parameters for the lookup strategy and how to provide optimal lookup.

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(Received February 27, 2012)
(Revised November 23, 2012)

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[Practical Paper] Life Log and its Application to Remote Consultation System

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Abstract -Recently, opportunities that a consumer has to make choices are increasing. And, needs of the remote consultation is rising as a means of making choices efficiently. However, the burden of the expert (consultant) is large in the existing remote consultation, because there is a large difference between numbers of customers and experts. Therefore, it is difficult to carry out a consultation that considers the customer's personality and personal preferences and that matches well to the customer's needs. In this paper, we propose a technique to solve these problems by applying life log for basic data acquisition in remote consultation and present useful application examples.

Keywords: Remote consultation; Life log; Home electric appliance; Care and health consultation; Recommendation

1 INTRODUCTION

Recently, people's needs and values become more multifaceted by diversification of individual lifestyles. As a result, businesses offer various services tailored to customers' individual needs and their opportunities for choice are increasing accordingly. As the means to assist consumers' efficient selection of services, demands for remote consultation are increasing [1]-[3].

In existing remote consultation systems, it is, by its nature, difficult to propose a solution tailored to each individual customer. On the other hand, teleshopping system, for example, Amazon.com [4], can recommend products best fitted to each customer by learning the customer's latent preferences from the customer's checking and purchasing history of products and understanding the customer's characteristics of potential purchases. However, if you attempt a recommendation like this in current remote consultation systems, you ask and enquire preferences from people who are seeking advice or recommendation, and after understanding them from their responses, you recommend products accordingly, or you divide people into patterns by age, sex, yearly income, etc. and make recommendation accordingly. In any case, the procedure that you follow cannot be said better in both efficiency and accuracy.

When making recommendations for customers' individual needs, we need quantitative information that reflects the customers' personality and personal preferences. In the conventional remote consultation system, the main purpose is the problem solving, and it goes along mainly on dialogue between customer and consultant (expert). Therefore, the quantitative information that we can get is limited to data, such as age, annual income, and family structure, which does not reflect customers' preference and characteristics. Such fewness of the customers' personal data indices can be considered causing inefficient and less accurate recommendations of the existing remote consultation system.

In this paper, we intend to facilitate the consultation tailored to individuals, by collecting and analyzing life log from home electric appliances and estimating the latent characteristics of each individual. We will also further consider the application field where our consultation method can be effectively utilized.

This paper is organized as follows: Our preceding work of remote consultation system and related works concerning life log applications are reviewed in section 2. Then, we provide an overview of this research and describe the system configuration in section 3. The method of applying this research to several application areas is given in section 4. Finally, conclusions and the future prospects are described in section 5.

2 RELATED WORKS

2.1 Preceding study

In our preceding research [2][5], we created remote consultation support system using outline generation agent in order to support interrupt and resume of the session in the process of consultation, and to facilitate better individual understanding for both customer and expert. In our research, we use outline to summarize the direction of the consultation, frequency of questions, transit time of consultation, and items that the customer wants to give higher priority by analyzing history of consultation process. Then the system visualizes the process of the consultation and makes the consultation task easier.

However there are some problems remaining with the system. For example, volume of information and efficiency is not sufficient enough because the system deals only consultation record as its analysis target and can get outline information only from customers' input, and also outline is used in limited situation and doesn't make sense in short consultation where interrupt and resume are not required.

2.2 Related study of life log

There are two patterns in study about life log, one study is about a method to get and reprocess life log and the other study is about a method for utilization of life log. Aizawa [6] [7] [8] realized an easy retrieval of life log video data using the query by combining life log video data with sensor data from GPS, gyro sensor, acceleration sensor, brain wave sensor and information database of weather and town etc. to assume context of life log and electronic document data. It is very useful to accumulate life log data combining with other relevant information and acquire life log data relevant to certain events easily. But, there are some problems when we apply life log video data to remote consultation. It can help to know the characteristics of individual customer, but it is a time consuming burden to expert because the data is made up of movie data.

Ito [9] achieved the improvement of the satisfaction and discovery characteristics of TV program recommendation by using the life log, such as viewing time of the TV programs, history of visited places, WWW browsing history. In life log made of "history" like this, there are chances that much valuable information is hiding because the customer does not need to keep a record consciously. If we could use such life log in remote consultation, we can change the current status of consultation where experts make a lot of questions to know the taste, the current state of the customer to the new status where experts acquire customer’s data from life log and we can expect to realize more efficient remote consultation.

There are many specific researches to utilize life log to specify preferences of users [10]. But there is no research which applies life log data to remote consultation like our research. If we could use life log to remote consultation, we think we can scale up the range of consultation from cases that allow mistakes to some extent like recommendation of daily products to cases that allow no mistake like health care consultation.

2.3 Home network

Home network technology operates home electric appliances such as refrigerator, home video etc., through home LAN. There are two types of researches of home network. One is the research of the communication protocol between the consumer electronics, and the other is the research about applications that use consumer electronics through the network.

As the example of the former case, ECHONET (Energy Conservation & HOmecare NETwork) is proposed by ECHONET Consortium [11]. It utilizes sensors and controls and manages home electric appliances over network, aiming at facilitation of energy efficiency and home care services. In 2002, "ECHONET Specification version 2.11" was defined and in 2008, "Version 3.60" was issued and also registered as an international standard [12]. Such as automatic lighting on when entering a room is often adhere to this ECHONET standard.

As examples of latter case, Lin et al. [13] proposed UbiREMOTE, and Sekimoto et al. [14] presented BAMBEE. UbiREMOTE displays the spatial layout of home electric appliances and home network on the remote control terminal to create a 3D virtual space, and the user selects the 3D graphics and operation menus to operate appliances by the centralized and intuitive manner. The user does not need to use many remote controls to operate various appliances. BAMBEE is a GUI system displayed on the touch screen. By simple operation, user can create and edit integrated services of home electric appliances. In this system, as well as for professional service providers, also for non-expert end users, it is possible to create applications easily. That can greatly expands the application range of integrated services of home appliances.

In this way, applications via the home network not only make the user's life more convenient but also promote efficient energy usage. However, these applications are mostly intended to send commands to the appliances via home network; we cannot find much study of handling life log and applying to various applications as we intend to do in our research.

3 PROPOSAL OF AN APPLICATION OF LIFE LOG TO REMOTE CONSULTATION

3.1 Outline of the research

Purpose of this research is to take advantage of personal information in daily life. We propose a system to get information of usage log from home electric appliances like TV, refrigerator, mobile phone and etc., then, to accumulate those logs through home network and to use it to remote consultation. We assume Android [17] based home electric appliances to access for getting life log. In addition, by using information obtained from these appliances, we discuss the application field of remote consultation support system to assist in the selection of products or service suited to personal preferences.

3.2 Life log

Typically, the word of life log means mainly video data like home video, and we use big machine like video camera for getting information. Consequently, it is hard to get life log easily from the point of mobility. However advancement of technology like mobile and wearable computer, and etc. enables us to get information with handy devices, e.g., a mobile phone with camera and GPS function. And services that gather and organize acquired information on the network as life log are provided from some providers already [18]. However we must make the log consciously like photo shoot in almost all of these services, and such data is fragmentary depending on the log-taker and log-taker may abandoned some data arbitrarily. Recently, it came to be able to acquire log information without user’s consciousness by the appearance of the Android consumer electronic, and the method of using the life log extended greatly. Examples of life log that can be obtained from home electric appliances are shown in Table1.

From home electric appliances with communication function like mobile phone, life log concerning an individual activity history like the sojourn time in a stay place and a specific base etc. can be acquired. From the consumer electronic for the amusement, life log concerning the characteristic of contents that the person watches, the contents type of the favor, and media, etc. most often used can be acquired. Moreover, from the life consumer electronic, a potential characteristic what the person values in life for food and clothing etc. and the life time pattern can be presumed. If the mentioned information can be used for the remote consultation, the difficulty to grasp individual characteristics can be solved.

Table 1: Life log examples from household electric appliances

Type of electric appliance	Name	Life log Data
Communication	Mobile phone	Daily activity log
Amusement	TV	Watched TV programs, Watching hours
	Radio	Listened Radio programs Listening hours
	DVD	Watched DVD software Watching hours and recording information
	CD	Listened music Listening hours
Daily life	Refrigerator	Used hours
	Washing machine	Used hours, weight, wash type
	Microwave	Used hours, cooking menus
Others	Car navigation	Mobile history

3.3 Acquisition of life log from consumer electronics

As an example of life log acquisition from consumer electronics, NTT DoCoMo has provided smart tap [15] and Zojirushi Co. and NTT have introduced watching electric pot (i-pot) that sends a signal to a regional treatment center every time the pour button is pressed [16] etc. The former is plugged into an electric outlet in the house and used, by connecting home appliances to it, to measure the amount of electricity used. The latter is an air pot with wireless LAN to send a signal to the network when the pour button is pressed and the signal confirms to care givers that the elderly persons under their care are safe. Most of these existing products are achieved by giving some external devices. When information is acquired like this, information is not retrieved correctly in some cases. For example, if the device is got off by external shocks, until it is noticed and fixed, information cannot be obtained. Also, the system is weak for arbitrary falsification of information by the customer.

In our proposed system, we process by software as much as possible without using such external devices. Android consumer electronics process interrupt instructions such as pressing a button by installed Android OS. This means that user applications can detect the interrupt instructions to get all the history of buttons used. By using external devices only where not using button operations, the aforementioned information leakage, tampering can be minimized, and it is possible to obtain information of life log close to individuals' real life. Although, Android consumer electronics that are currently sold are very few, for example Android TV, Android refrigerator are in the market, we expect wide variety of Android based appliances come out in the near future.

3.4 Outline of the proposed system

We show framework of the proposed system in Fig. 1. Home electric appliances send life log to cloud service regularly. Cloud service deposits life log data and arranges, processes according to the usage. When the expert requires, processed life log are once sent to the customer, and after customer's approval for the sake of privacy, the life log is forwarded to the expert. By using life log data in this framework, we can utilize remote consultation system applying life log data regardless of the place you stay.

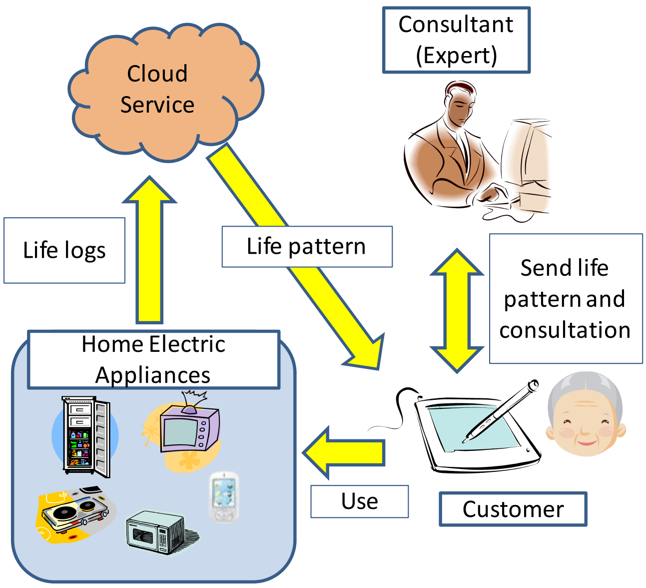

Figure 1: Framework of the proposed system

3.5 Process of life log

In this study, we get life log data from many tools. As a result, the volume of data that we treat in the system becomes very large and there exists a lot of data which identifies each individual. Therefore, when we use the data in remote consultation system, we have to process data and make it easier to apply to the application field (see Fig. 2), and protect the privacy of the customer. The method of data process changes according to the target area of remote consultation. For example, when we apply this system to the area of elderly people's care, we can propose a care plan that match to the customer's life pattern, such as ordinary daily life pattern or specific occasion's life pattern, etc., from life log of mobile phone's mobile history, time record that the customer used home electric appliances first in the morning, etc.

As an example in the area of care support, the simplest way to create and use a life pattern is shown in Fig. 2. Information acquired is as follows.

(1) Movement history from a mobile phone with GPS
(2) First and last time to use consumer electronics in a day
(3) Duration of usage of appliances related to cooking
(4) Duration of usage of appliances related to entertainment
(5) Duration of usage of bathroom equipments

From (1), the person's movement pattern and habitual outing can be derived. Moreover, a cycle to go out to see a doctor or the time to stay in health-related facilities can be acquired. Based on this information, the future planning for various activities including medical examination, etc. can be efficiently achieved. From (2), person’s activity hours can be got. And personalized service can be provided by giving care support according to this time schedule. From (3), food and their time trends can be obtained. By analyzing the equipment used by the customer, you can guess whether the customer is having a healthy diet or the food is cooked properly. For example, the customer doesn’t use any electric appliances other than refrigerators, or only the warm menu of the microwave oven is used, you can guess the problem with the dietary habits. As for microwave, because various recipes and variety of cooking function are given, you can get even more information. Based on the information, food policy can be constructed and it becomes possible to determine whether a diet-related services as nursing care should be recommended or not. From (4), the leisure time can be estimated. And health or care visits can be arranged smoothly. From (5), the time to bathe and the person is taking bath properly or not may be determined. Based on the information, whether the bathing care should be introduced, and when should be decided. From various kind of information, daily life patterns can be read, and patterns that differ significantly by the week or by the day of the week can be identified. Then by integrating those patterns and estimating the daily life patterns, various services can be created effectively for the customer.

4 APPLICATION FIELDS

In this section, we take up some of the application fields such as care and health consultation, travel planning consultation and consider about applicability and the convenience for the user in each field.

4.1 Care and health consultation

In Japan, needs of consultation related to physical condition of elderly people are rising from the effect of rapid aging society. For example, consultations about preparation of the care plan which includes what kinds of care support the customer needs, plans for care taker’s visit schedule, etc (see Fig. 3). The problem of the consultation is intractableness of getting necessary customer’s information because customer is often old and sometimes information is taken from customer’s family. They forget many things that are necessary for the consultation, and they don't report all the matter of necessity because they haven’t enough knowledge of care. In some cases some people put on an impressive show. For example, they say "It is possible" regardless they can really do it or not. As a result, there are some cases that expert can't specify cause of bad health and the customer can't undergo appropriate treatment.

If we apply life log to care and health consultation, expert can get all the necessary information without customer’s burden to record. If we are working on the care plan through consultation, the system can also check the degree of attainment of planned schedule using history of usage of home electric appliances. In this way, when we add life log in care and health consultation, we can realize high quality service and more adapted service to the customer.

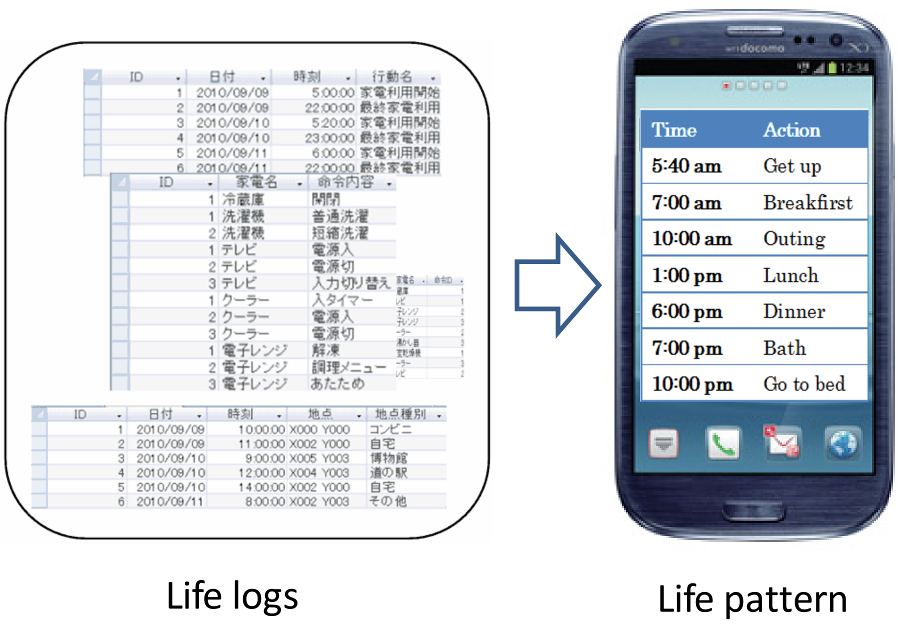

Figure 2: Life pattern deduced from life log data

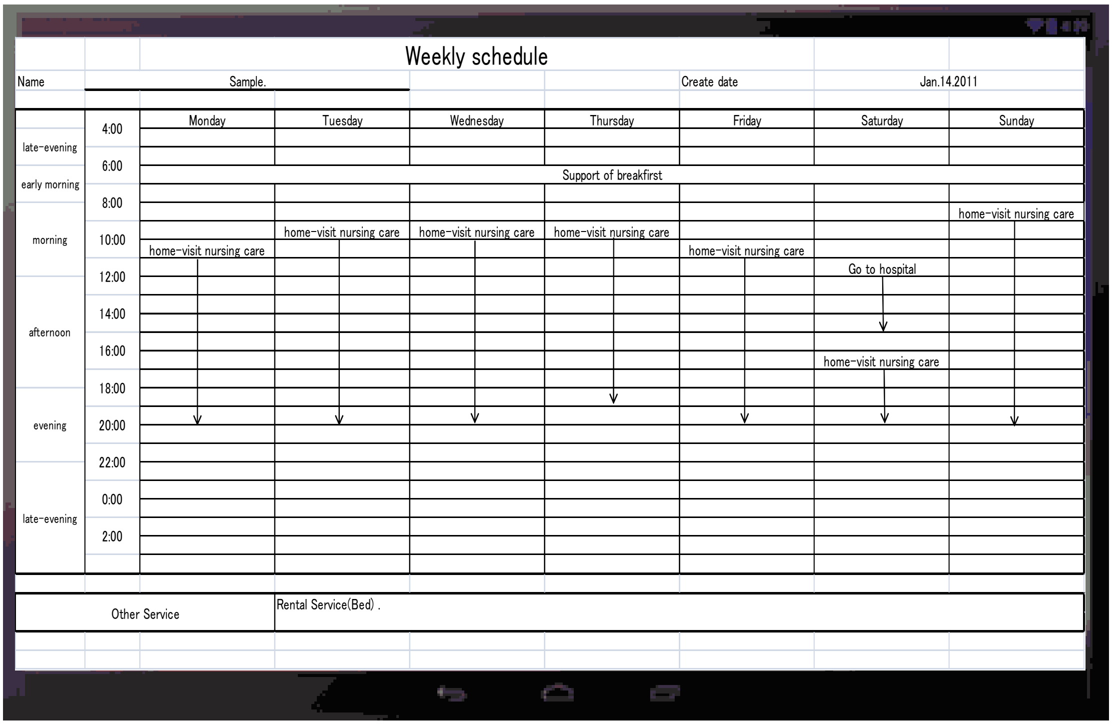

Figure 3: A sample of care plan for elderly people

4.2 Travel planning consultation

We can travel more easily by the spread of service for the trip arrangement using internet. However, researches of travel planning consultation are increasing [19]-[23] because needs of travel consultation for customers who have no specific destination or have specific destination already decided, but have no detailed plan are increasing more widely ever. But in these preceding researches, user's preferences are extracted from some direct enquiries to the customer or certain typical patterns are identified from customer's age, sex, annual income, etc. and recommendations are given based on the patterns. In order to manage a practical travel planning service, we need a huge amount of past user data and user's preferences.

Preceding systems require much effort to match to individual customer's preferences and still hard to achieve detailed consideration about personal preferences such as sojourn time at a certain visiting place. For example, a tourist probably spends more time at the visiting places that fit his/her interest. Also, some older people prefer slower tours. Thus, it is desirable that the system can estimate the time spent at each visiting place by each user, for instance, based on a certain statistical model.

By applying life log data to the consultation, the customer can deliver his preference without complicated input. Therefore, system can make the travel plan that match to customer's preferences without forming stereotypical patterns of customers. And if the system gets stay time at per kind of facilities from GPS data of a mobile phone, the system can match the sojourn time of the destination in facilities to the individual's preference. Trajectory data [19] of a user which

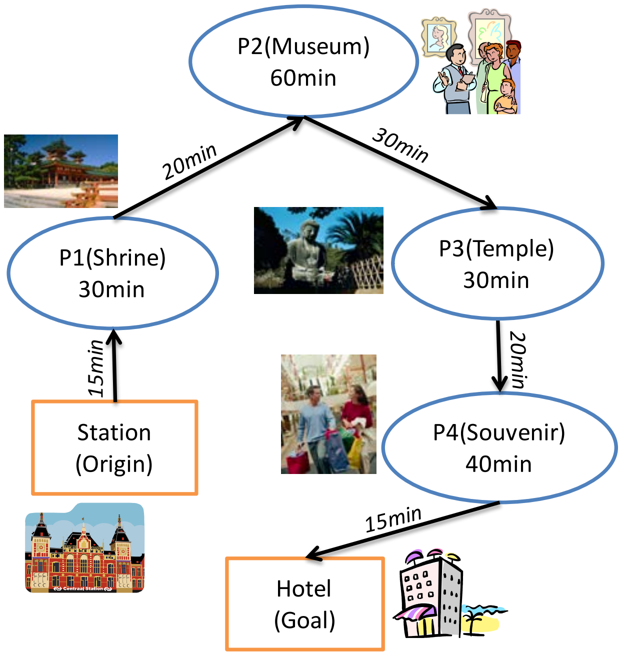

Figure 4: Sample solution for a better tour plan based on the user's preference data

show how much time he/she spends at a certain visiting point should tell something about his preference. More microscopic trajectory data to analyze the user's action in detail, what kind of routes the user prefers and where and how long the user spends time may be very useful. This way, as shown in Fig. 4, we can make up a solution for a better tour plan based on the user's preference data

5 CONCLUSION

In this paper, we presented how to get life log using the home electric appliances and examples of application field such as care health consultation, travel planning consultation. As a result, we could understand that it is very useful and it has a multiplicity of uses in consultation that closely attached to individual life, and in decision that based on individual preference. In the future, we will follow trends of home network and the development of Android-based household appliances further on to pursue feasibility of the proposed concept and system. We will continue to consider effective method of life log data processing and check the further applicability of life log data from the home electric appliances to remote consultation by constructing the actual application systems.

ACKNOWLEDGMENT

This work was supported by JSPS KAKENHI Grant Number 12345678.

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(Received June 30, 2011)
(Revised February 27, 2012)
(Revised February 26, 2013)
(Revised April 2, 2013)

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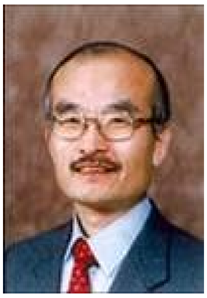

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